A Report on Historic and Contemporary Patterns of Change in Hawai'i-Based Pelagic Handline Fishing Operations—Final Report

Edward Glazier, Janna Shackeroff, Courtney Carothers, Julia Stevens, and Russell Scalf

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Abstract

This report summarizes key findings from two PFRP projects that were designed to examine change in Hawai'i's small-boat commercial handline fisheries. The first study examined historical aspects of handline fishing in the islands, and diminishing participation and production in the ika-shibi fishery, a long-standing and once-lucrative yellowfin and bigeye tuna fishery specific to Hawai'i Island. The second study examined the history and contemporary status pelagic handline operations at Cross Seamount and at private fish-aggregating devices (PFADs) around the islands. Data sources included catch and effort data, seafood dealer data, direct observation of handline operations, review of pertinent literature, analysis of regional employment information and other relevant data, and numerous in-depth interviews with participants in the harvest and distribution sectors. Research findings counter the working hypothesis of a widespread shift from ika-shibi fishing to fishing at PFADs. Convergence between a variety of social, demographic, and economic factors amidst a period of diminishing availability of tuna better explains the current status of the ika-shibi fishery and ongoing challenges in the PFAD fishery. While the availability of tuna is obviously pivotal to the status of the fisheries in question, tuna populations are subject to a complex array of biological, oceanographic, and human interactions. This report furthers understanding of the human context of small-scale pelagic fisheries in the Hawaiian Islands, with implications for the management of pelagic fisheries elsewhere in the Pacific Basin.

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1. INTRODUCTION

The following pages describe the small-boat pelagic handline fisheries of the Main Hawaiian Islands (MHI), and the social and economic factors that have conditioned participation in those fisheries over time. The report is based on two projects completed for the Pelagic Fishery Research Program (PFRP), Joint Institute of Marine and Atmospheric Research, School of Ocean and Earth Science and Technology at the University of Hawai'i at Mānoa. The project titled "Human Dimensions Research of Hawaii's Ika-Shibi Fishery" was initiated in 2004 to identify factors associated with diminished involvement in a long-standing and once highly lucrative fishery specific to Hawai'i Island (alternately termed the Big Island). A closely related project titled "Small-Boat Commercial Bigeye and Yellowfin Tuna Operations and Regulatory Scenarios in the Main Hawaiian Islands" was initiated in 2005 to enhance understanding of handline operations at Cross Seamount and at private fish aggregating devices (PFADs) around the islands.

Both projects involved extensive archival research and analysis, and overlapping research interaction with public officials and fishermen currently or formerly active in either or both of the fleets of interest. Findings from each of the studies have been presented to the Western Pacific Regional Fishery Management Council (the Council) and both its Pelagic Plan Team and Science and Statistical Committee in advance of management decisions regarding component(s) of the handline fleet active in the Main Hawaiian Islands.

1.1 Administrative Background

The PFRP was established in 1992 to provide scientific information to the Western Pacific Regional Fishery Management Council. The Council continues to use such information to better understand and manage biophysical and social aspects of the fisheries under its jurisdiction across the U.S. Exclusive Economic Zone (EEZ) of the Central and Western Pacific. These include fisheries conducted by fleets based in the Hawaiian Islands, American Samoa, the Commonwealth of the Northern Marianas, Guam, various remote island areas, and in the vast open ocean areas that surround the archipelagos. In conjunction with the U.S. Department of Commerce National Marine Fisheries Service (NOAA Fisheries), the Council monitors fisheries and marine resources in the region and develops and adjusts policies to ensure their sustainability over time. Given the importance of pelagic fish and fisheries to island societies throughout the Western Pacific, the PRFP plays a critically important role in this collaborative process.

1.2 Information Need and Rationale

The stock structure and migratory patterns of tuna species in the Pacific Ocean are subjects of extensive and ongoing research. Some tuna species, such as bigeye (*Thunnus obesus*) and yellowfin (*Thunnus albacares*), are important sources of food and revenue for people across the Pacific. They are therefore subject to extensive fishing pressure. Regional and Pacific-wide stock assessments indicate that maximum sustainable yield for these species has been collectively exceeded by the various fishing fleets active in this broad region (Hampton et al. 2004; Harley and Maunder 2004; Hampton et al. 2003). In 2004, NOAA

Fisheries determined that bigeye tuna was being overfished across the Pacific. In 2006, the agency determined that yellowfin was being overfished in the Western and Central Pacific.[1] Subsequent to these determinations, the Council acted to address fishing-related pressure in its area of jurisdiction, with due attention to greater pressures occurring elsewhere in the Pacific Basin.

But efforts to assess and effectively manage bigeye and yellowfin stocks in the Central and Western Pacific are complicated by a range of factors and circumstances. These include the following: (a) the movements and migratory patterns, foraging behavior, stock structure, trophic status, and oceanographic factors associated with these species are complex subjects of ongoing research (e.g., see Sibert et al. 2006); (b) fishing pressure that occurs in association with various types of gear deployed by both domestic and foreign fleets across the Eastern, Central, South, and Western Pacific; (c) diverse fishing activities that are regulated by multiple island and continental government agencies and regional entities, including the Western and Central Pacific Fisheries Commission, the Pacific Islands Forum Fisheries Agency, the Secretariat of the Pacific Community, and the Western Regional Pacific Fishery Management Council; and (d) some stocks may already be, or are perceived to be, or are said to be, in a state of decline, for whatever reason(s), thereby increasing both the challenges to and urgency of implementing effective management measures.

The situation is further complicated by the need for management decisions that effectively balance the benefits of conserving bigeye and yellowfin stocks against the potential costs of such measures for fishery participants and consumers of seafood landed in the region. In this regard, various data are needed to better understand how, why, and to what extent bigeye and yellowfin are pursued and landed in the region, and how fishing activities might be modified to ease human pressures on the populations while minimizing potentially adverse economic and social effects for people who pursue and/or consume the resource. This report contributes to such understanding by describing fisheries that involve a relatively small volume of landings, but which are of importance to participants and consumers of pelagic seafood in the Main Hawaiian Islands.

As noted earlier, numerous fleets exert pressure on tuna populations in the Pacific Basin. Hawai'i-based fleets are, in fact, responsible for only a small fraction of overall effort. Indeed, the Hawai'i-based longline fleet (of 121 active vessels in 2007), typically accounts for only about five percent of Pacific-wide longline fishing effort in terms of total hooks set per year (Western Pacific Regional Fishery Management Council 2003). Although this fleet is periodically active in the EEZ around the Main Hawaiian Islands, most longline fishing occurs in more distant waters. The longline fleet is focused on capture of tuna and swordfish, while the small-boat commercial fleet in Hawai'i is focused primarily on capture of tuna, primarily bigeye and yellowfin—the two consistently most valuable species of tuna. Aku or skipkjack tuna (*Katsuwonus pelamis*) and tombo or albacore (*Thunnus alalunga*) are also commonly landed. Other pelagic species such as

[1] A 2007 stock assessment for yellowfin indicates Pacific stocks are fully exploited and that the most pressure occurs in the equatorial zone (Secretariat of the Pacific Community 2008). A stock assessment undertaken for the Western and Central Pacific Fisheries Commission in 2008 indicates overfishing of bigeye in the Pacific, and that significant exploitation of juvenile bigeye is associated with purse seine operations which set over floating objects, and in association with the domestic fisheries of the Philippines and Indonesia (Secretariat of the Pacific Community 2009).

mahimahi or dolphin (*Coryphaena hippurus*), ono or wahoo (*Acanthocybium solandri*), and various a'u or marlins, such as Pacific blue marlin (*Makaira mazara*) and nairagi or striped marlin (*Tetrapturus audax*) are also often landed by the longline fleet and small-boat commercial handline and troll fleets.

Although underreporting and misreporting of landings[2] constrain a completely accurate picture of catch and effort on the part of Hawaii's small-boat fleet, it is clear that small-boat[3] commercial landings consistently represent only a small percentage of overall landings by all Hawai'i-based commercial fishing fleets, which include longline operations, small-boat operations, and aku boat operations. Reported landings for the entire commercial small-boat fleet—including small vessel trolling operations, nearshore handline operations, offshore handline operations, and mixed gear use throughout—comprised about 18 percent of total reported commercial landings of pelagic species for all Hawai'i-based commercial fleets in 2004.[4] In 2006, combined small-boat commercial pelagic landings were about 16 percent of the total reported landings for all Hawai'i-based commercial fleets.

The persons in the harvest sector of the small-boat commercial handline fisheries who are the subject of this study reported landing an even smaller percentage of the total commercial catch in the islands. That is, Hawaii's nearshore and offshore handline operators reported landing only about 1.8 million pounds of pelagic fish in 2004, or about seven percent of the combined total of Hawai'i-based commercial landings. In 2006, reported landings for this fleet totaled about 1.2 million pounds or about five percent of the total. Landings trends for the entire Hawai'i-based commercial fleet for the period 1987 to 2006 are depicted in Table 1.

While the volume of pelagic fish landed by the small-boat commercial handline fleet in Hawai'i is quite small relative to that of the overall Hawai'i-based commercial fleet, and miniscule relative to that of commercial fleets Pacific-wide, the harvest, the process of fishing, and the secondary benefits of fish and fishing are highly significant to small-boat fishery participants and other residents in the Main Hawaiian Islands. Fishing for pelagic species at this small scale of operations provides: jobs for captains and crew members; a source of food in extended family, community, and island settings; and a

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[2] Participants in the commercial harvest sector generally do report their catches in an accurate fashion, but not always. This problem is by no means specific to Hawai'i; rather there is some degree of misreporting and underreporting of landings and effort across all managed fisheries in the U.S. and abroad. Determining the full extent of the problem is a study in itself.

[3] "Small-boat" is loosely defined in this report to include vessels of a size that can be transported by trailer—typically not much longer than about 32 feet in length overall (LOA). But given variation in vessel size across the fleet, somewhat larger boats may also be included. Vessels frequenting Cross Seamount and other offshore areas are typically significantly longer. Hamilton and Huffman (1997) report that palu 'ahi boats are typically ~20 feet LOA, ika-shibi boats are typically ~26 feet LOA, and seamount boats are typically ~40 feet LOA or longer.

[4] Some use of troll gear is common across the Hawai'i small-boat commercial fleet, and dedicated troll fishermen sometimes use handline gear. These categories are thus not hard and fast but are used here to capture the long-term focus of the operations. Nearshore handline operators tend to use handline gear on a regular basis within about 20 miles from land. Offshore handline operators tend to use handline gear on a regular basis at distant seamounts and weather buoys, as far as 200+ miles from land.

means for enacting a locally valued way of life (see Glazier 2007). The full value of the fishery cannot, therefore, be adequately expressed in terms of total landings or market value of the fish. Its value should rather be expressed as a composite of economic, dietary, and cultural dimensions. This is true for small-scale and other fisheries throughout the Pacific.

Table 1. Trends in pelagic landings for Hawai'i-based commercial fleets: 1987-2006

Year	Longline	Nearshore		Offshore Handline	Aku Boat	Total
		Troll	Handline			
1987	3,891,000	3,709,000	1,914,000	-	3,503,000	13,024,000
1988	6,710,000	2,445,000	1,470,000	-	3,940,000	14,566,000
1989	9,942,000	2,401,000	1,487,000	-	2,962,000	16,837,000
1990	14,738,000	2,901,000	1,060,000	66,000	1,116,000	20,249,000
1991	19,478,000	3,102,000	1,477,000	331,000	2,146,000	26,535,000
1992	21,105,000	2,395,000	946,000	987,000	1,735,000	27,167,000
1993	25,005,000	2,578,000	1,532,000	679,000	2,137,000	31,931,000
1994	18,134,000	2,810,000	1,287,000	1,175,000	1,159,000	24,565,000
1995	22,723,000	2,966,000	1,733,000	714,000	1,291,000	29,430,000
1996	21,553,000	2,994,000	1,962,000	793,000	1,844,000	29,149,000
1997	27,145,000	3,016,000	1,479,000	563,000	1,947,000	34,150,000
1998	28,629,000	2,470,000	1,368,000	1,134,000	845,000	34,447,000
1999	28,348,000	3,014,000	2,413,000	888,000	1,312,000	35,975,000
2000	23,818,000	2,559,000	1,728,000	1,482,000	708,000	30,342,000
2001	15,804,000	3,738,000	2,072,000	1,087,000	994,000	22,782,000
2002	17,405,000	2,388,000	1,702,000	1,059,000	932,000	23,611,000
2003	17,647,000	2,692,000	1,091,000	399,000	1,375,000	23,459,000
2004	18,483,000	3,353,000	1,386,000	485,000	656,000	24,705,000
2005	23,334,000	2,561,000	1,202,000	392,000	931,000	28,607,000
2006	21,552,000	2,482,000	668,000	487,000	661,000	26,138,000
Average	**19,272,000.2**	**2,778,000.7**	**1,498,000.9**	**636,000.1**	**1,609,000.7**	**25,883,000.5**

Source: Western Pacific Regional Fishery Management Council (2007); figures rounded to nearest thousand pounds

1.3 Historical Overview

1.3.1 Ancient Beginnings

Deep-sea fishing has long been an important aspect of life in the Hawaiian Islands, and the use of handlines to capture various tuna species is the most enduring form of fishing in the region. Deep-sea fishing sustained the first voyagers who reached Hawai'i by canoe, and it sustained Hawaiians for many centuries on each of the main islands, and also on Nihoa Island (and less certainly on Necker Island) in the Northwest chain (Kirch 1985). Pelagic fishes were originally consumed directly by nucleated groups of residents, but as society increased in size and complexity, fish became an important commodity for trade in and between ahupua'a and mokus[5] (Sahlins 1992).

[5] Ahupua'a are land divisions wherein available resources from mauka (mountain) to makai (sea) are effectively managed and utilized by residents. Mokus are political districts, the boundaries of which encompass multiple ahupua'a.

1.3.2 Social Change

As Hawaiian society and culture were increasingly disrupted through contact and interaction with Europeans, so also were the social processes that sustained deep-sea fishing, such as the expert crafting of hooks (makau), lines (aho), and canoes (wa'a). Europeans brought the concept of private ownership of land, a variety of contagious diseases, Christianity, and the cash economy, each of which led to profound social change in the Hawaiian Islands.

By the mid- and late 19th century, Hawaiians were fishing the depths for pelagic species primarily for purposes of consumption by the extended family ('ohana). Fully functioning ahupua'a were increasingly rare. Many Hawaiians necessarily engaged in the cash-based economy and some fished to earn money. Certain fishing methods and related cultural practices that were developed in ancient times were practiced even during this period of dramatic change (McGregor 2007). Some such methods and practices continue to this day.

1.3.3 Japanese Immigrants and the Ika-Shibi Fishery

Some immigrants arriving from Japan around the turn of the 20th century adapted quickly to economic conditions in Hawai'i. Some brought fishing skills and a readiness to engage in local commerce. A productive commercial fleet and venues for the sale and distribution of seafood were developed in part with capital transferred from accounts in Japan (Schug 2001). Some issei (first generation immigrants from Japan) and nissei (second generation residents of Japanese ancestry) developed means for catching tuna with handlines, using ika (squid) for bait, and a new era of productive local handline fishing was initiated. World War II interrupted the fishery, though it began to rebound in the early 1970s, with periods of increasing participation in the mid-1980s and again in the late 1990s. Participation and production have declined significantly in recent years.

1.3.4 The Cross Seamount and Weather Buoy Handline Fishery

Another distinct pelagic handline fishery was developed in the early 1970s when enterprising fishermen began to take advantage of tuna aggregations at Cross Seamount, some 150 miles southwest of Hawai'i Island. Fishing also gradually occurred at the offshore weather buoys after these were established in the early to mid-1980s. The "far offshore" fishery was highly profitable for some operators. Participation and production peaked in the late 1980s and early 1990s. Given rising fuel costs and other challenges, relatively few operators now frequent these areas.

1.3.5 Handlines as Auxiliary and Recreational Gear

Contemporary small-boat operators who pursue pelagic fish around the Main Hawaiian Islands occasionally use a variety of gear types in conjunction with or as an alternative to trolling gear. Such persons typically fish for a combination of purposes that involve commercial sale and/or consumption and sharing of the catch, and recreation. While the extent of landings associated with recreational use of handlines and other gear is not well known in Hawai'i, the reliability of catch estimates for recreation and consumption-oriented boat fishing in Hawai'i is likely to improve in future years in conjunction with evolving sampling and analytical components of the Hawai'i Marine Recreational Fishing Survey, now undertaken throughout the main islands.

1.3.6 The Effect of Social Forces on Fishing Capacity

The capacity to fish is, in many ways, related to constraints and opportunities associated with distant or external social and economic processes and forces. For example, foreign ideas and materials led to the reordering of society in old Hawai'i, and the social structure that had long supported deep-sea fishing subsequently faltered. Japanese immigrants were successful in the commercial fishing industry until World War II interrupted fishing throughout the islands. Commercial handline methods were reinstituted after the War and improvements in hull materials and engines, spurred in part by wartime naval needs, improved the safety, range, and effectiveness of local fishing operations. More recently, general advances by firms specializing in navigation and positioning technologies have significantly improved the safety and efficiency of deep-sea fishing. In economic terms, participation and production in commercial handline fishing in Hawai'i has continually expanded and contracted in recent decades, at least partly in association with changing opportunities in the land-based job market, a market that is significantly affected by conditions on the U.S. continent and elsewhere. Finally, contemporary participants in the handline fishery are increasingly constrained by the price of petroleum-based fuel, a resource that is in great demand and subject to market forces that are global in nature.

1.4 Purpose and Objectives of the Projects

The intent of the projects described in this report was to assess patterns of change in Hawai'i-based handline fisheries and satisfy information needs regarding small-boat pelagic handline operations and the use of private fish aggregating devices (PFADs), short-longlines, and other non-longline fishing gear used around the MHI. Such information was generated through extensive fieldwork and archival research conducted by the contractor on behalf of PFRP. Three basic objectives were met during the course of the projects; these are as follows:

(1) Review trends in Hawaii's offshore small-boat pelagic handline fisheries, as these have been conducted around PFADS, FADs, weather buoys, and seamounts using ika-shibi, palu 'ahi, short longline, and other passive hook and line gear; address catch volume, rates, and composition, gears used and areas fished, and number of participants in each fishery;
(2) Examine the current status of each fishery, focusing on the same topics as above; and
(3) Examine potential future management needs, such as limited entry and other options.

1.5 Research Methods

A variety of research methods were used to conduct the research described in this report. These include: compilation, review, and analysis of historical documents and data; social network sampling procedures to identify highly knowledgeable fishery participants; in-depth interviews with fishery participants and persons knowledgeable of historic aspects of the fisheries; and various methods of observation typically used in the social sciences. Well over 200 interviews and many hundreds of hours of observation were conducted in association with the projects described here.

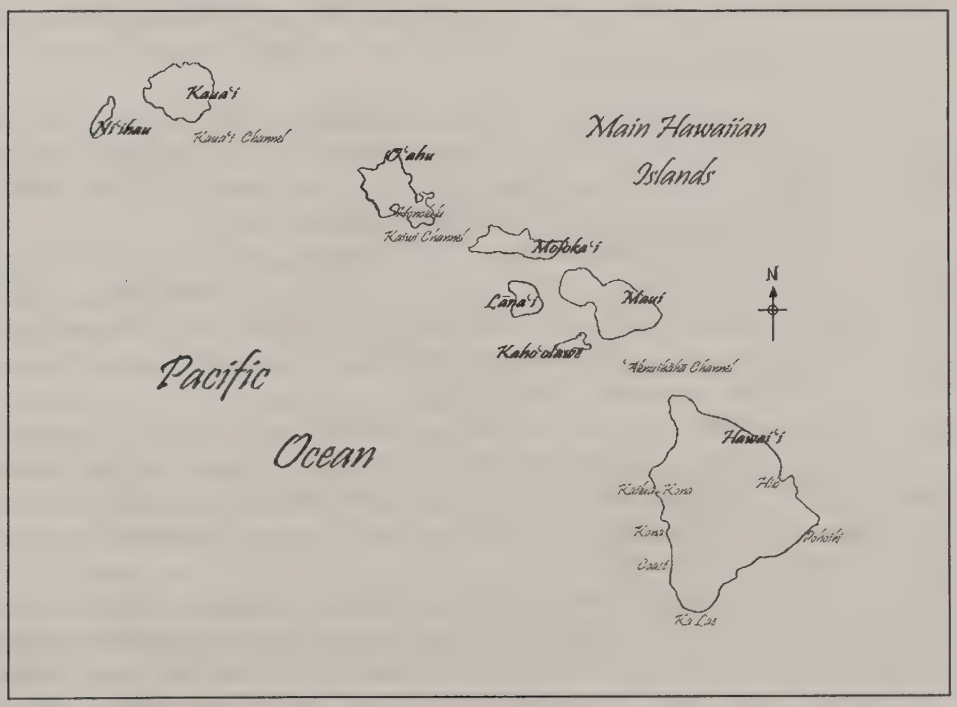
1.6 Organization of the Report

This document is organized in relation to the objectives discussed in Section 1.4 and per the chronological development of the Hawai'i small-boat handline fishery. This introductory section summarizes the central issues, information needs, purpose and objectives, and research methods.

Section 2 describes historical aspects of handline fishing in Hawai'i, with associated description of the fisheries themselves. The past is discussed in some depth because: (a) it provides insight into the way in which the fisheries have evolved in the islands and the significant effects of social and economic change on their conduct in the present, (b) it is often of great significance to Native Hawaiians, to other ethnic groups in Hawai'i, and to students of history in general, and (c) some gear and methods still in use in the islands have evolved from gear and methods used in old Hawai'i.

Section 3 describes more recent historical trends and contemporary conditions in the fisheries. The primary intent of the section is to provide descriptive data in support of project objectives one and two.

Finally, Section 4 is more analytical in nature. Major trends and changes in Hawaii's handline fisheries are revisited, and these are explained in relation to various social, economic, and cultural factors affecting the fisheries from within and without. Historical analysis again bears relevance as it makes clear that macro-social processes have recurrently affected small-boat fisheries in Hawai'i and are likely to do so in the future. Management issues and options are discussed in keeping with project objective three.



2. A BRIEF HISTORY OF HANDLINE FISHING IN HAWAI'I

This section describes historical aspects of pelagic handline fisheries in Hawai'i. The discussion is based on: archaeological evidence; materials written before and during the Plantation era; and reports and data from more recent periods. The historic description ends at 1985. This was the point at which the State of Hawai'i began to systematically compile and maintain data useful for analyzing participation and production in the region's commercial handline fisheries. The more recent period from 1985 to the present is discussed in subsequent sections of the report.

2.1 The Pre-Contact Era

2.1.1 Ancient Beginnings

The Polynesian mariners who originally explored Oceania reached what came to be called Hawai'i in part because they were skilled at deep-sea fishing. Groube (1971) asserts that early Polynesians were in fact a truly maritime people. Although horticultural activities were important, Polynesians dwelled primarily along the shorelines and traded fish for other essential items while traveling through the various archipelagos over the course of time. Pelagic fishing methods were necessarily used around high islands such as the Marquesas (Oliver 2002), and tunas and other pelagic species undoubtedly sustained travelers during voyages between some of the most remote islands on earth.

The acquisition of protein from fish and other marine resources was thus a familiar pursuit and an essential aspect of early subsistence and trade economies in the Hawaiian Islands. Efficient mechanisms were developed to land and distribute all kinds of seafood, including pelagic fish species. As time passed and new cultural influences were encountered, age-old methods were modified and existing knowledge about marine resources was alternately valued, modified, or lost.

Given that Hawaiians held and transmitted knowledge through mo'olelo (stories), accounts of the past often derive from this oral heritage. The archaeological record also provides an account. The following pages report on a combination of these sources, and later, the written accounts of explorers and indigenous participants.

There are considerable differences between estimates for when Hawai'i was first colonized. According to Kirch (1985), Cordy (2002), and others (e.g., Streck and Watanabe 1988), it may have occurred as early as 300 A.D. or even earlier. Oral tradition is indefinite regarding the place and timing of the arrival of the voyagers and settlement of the Hawaiian Islands (Malo 1951).

In any event, the early settlers undoubtedly possessed highly refined fishing skills and gear. Goto (1986) notes that the earliest evidence of fishing found to date in the Hawaiian Islands is at the Bellows site on O'ahu, where one- and two-piece fishhooks are found in conjunction with fish bones and mollusk shells in a soil layer dated to as early as the 4th century A.D. (Tuggle et al. 1978).

Evidence from sites in Hālawa Valley on Moloka'i suggests that residents were heavily dependent on marine resources for at least seven centuries, beginning in the fifth century (Kirch 1974). Evidence of sustained fishing activity has also been recovered at Ka Lae (literally "the Point," meaning South Point) on Hawai'i Island. Upwelling associated with colliding currents made and continue to make this a highly productive, if treacherous, fishing locale. Kirch (1985) suggests that some of the archaeological

assemblages at Ka Lae may date to the same period as the Bellows site. A wide range of fishing activities occurred in this area in antiquity, evinced by the presence of one- and two-piece fishhooks, aku lure shanks and points, crescent points used on large wooden hooks for sharks and pelagic species, and various sinkers (Goto 1986).

2.1.2 Fishing and Fish: Central to Life and the Organization of Ancient Society

Ancient Hawaiians distinguished by name the waters along the coast (lihi kai), the place before the waters become very dark (kai lū he'e), the fishing grounds (various ko'a), and the dark blue sea (kai pōpolohua mea a Kāne), among others (Kamakau 1976). The sea was further distinguished in terms of visual characteristics, the resources that might be pursued there, or the activities for which a certain zone was used. Words for waves and sea states captured the finest distinctions. In *The Works of the People of Old* (1976), Kamakau asserts that there were as many types of fishing as there were fish and that Hawaiians were adept at all of them; he states that "as fishing was done by the ka po'e kahiki (assembly of ancients) so it is done now, it is impossible to improve on their methods."

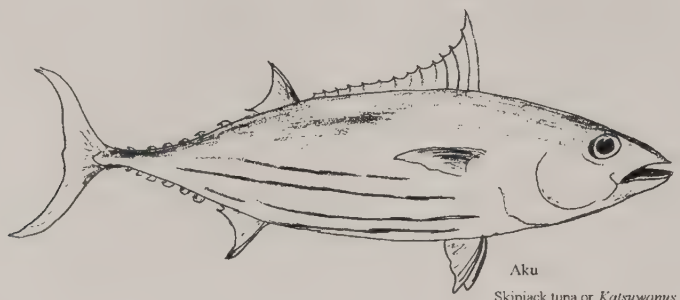
Life for ancient Hawaiians naturally involved a deep association with resources of land and sea. Political boundaries were defined in large part by the bounds of the rugged landscape and adjacent ocean, and upheld by the power of the chief and the loyalty of his people (Sahlins 1992). While early colonies may have been organized in a relatively egalitarian fashion, societies clearly became more complex over time and ali'i (royal chiefs) eventually led hierarchies of royalty and commoners. Residents specialized in various activities required for subsistence and trade-related interaction, and at times warfare with inhabitants of other ahupua'a, moku, and islands. Among the highest status individuals were the konohikis or managers- some of whom cared for shoreline and ocean resources and activities- and the lawai'a haku or master fishermen (Kamakau 1976).

Spearing fish and gathering shellfish such as 'opihi (*Cellana spp.*), crabs, urchins, and limu (seaweeds) along the shoreline were daily activities in any given ahupua'a. Women were often responsible for the gathering of shellfish. The nearshore zone was also productive and much fishing took place there with hukilau (seine) nets and pole and line. Fishponds provided a consistent source of protein after the fourteenth century, as is well documented in the literature (e.g., Apple et al. 1975, Kirch 1985). Seafood was complemented with kalo (taro or *Colocasia esculenta*), sweet potatoes, and other resources gathered or produced in the upland portions of the ahupua'a. Fish bones are found in upland as well as coastal sites (Goto 1986).

Archaeological analysis of fish bones found at camp and village sites in ahupua'a across the Hawaiian Islands suggests that offshore food resources were generally pursued with less frequency than those in the nearshore and shoreline zones (Kirch 1985). Goto (1986) concurs and states that "it seems that Hawaiians generally preferred using inshore [nearshore] resources, where and when they were available, to using offshore resources." This may be due to relatively fewer fish at depth, the increased difficulty and risk of fishing in the offshore zone, a gap in the archaeological record, or a combination of these factors.

2.1.3 The Importance of Pelagic Species

But deep-water fishing did indeed occur. Kirch differentiates a benthic zone of exploitation between 30 and 350 meters in depth and a deep-sea zone beyond. The Hawaiians pursued bottom fish such as ulua and ʻōpakapaka in the former and pelagic species in the latter, with a particular focus on aku. Handline fishing occurred in both zones.



Aku
Skipjack tuna or *Katsuwonus pelamis*

Goto (1986) suggests that the extent of pursuit of pelagic species varied across the Islands, depending on practical considerations such as the tendency of seasonal sea states to restrict availability of nearshore resources and ease of access to offshore waters. He notes such differences between the Waikīkī and Waiʻanae areas on Oʻahu. Reef fish species are abundant in the archaeological record at Waikīkī sites, where shoreline fishing activities were possible almost year round. Benthic and pelagic species are more common at Waiʻanae sites, where there is less fringe reef and where deep water offers good possibilities for successful pelagic fishing.

The idea that nearshore areas were favored areas for fishing may also have a political explanation. For instance, Scobie (1949) cites Campbell (1819) to assert that ahupuaʻa boundaries were highly contested inside the point at which breakers would occur. If an ahupuaʻa did not have a protected nearshore zone, residents would have to go to the deep sea to fish rather than seek nearshore resources in another ahupuaʻa. But in some cases, kuleana (rights and responsibilities) extended to fishing locations and resources in the offshore zone as well (Kamakau 1976).[6] Even very specific grounds and resources in distant waters of the deep sea could be located by triangulating between landmarks (Kahāʻulelio 2006).

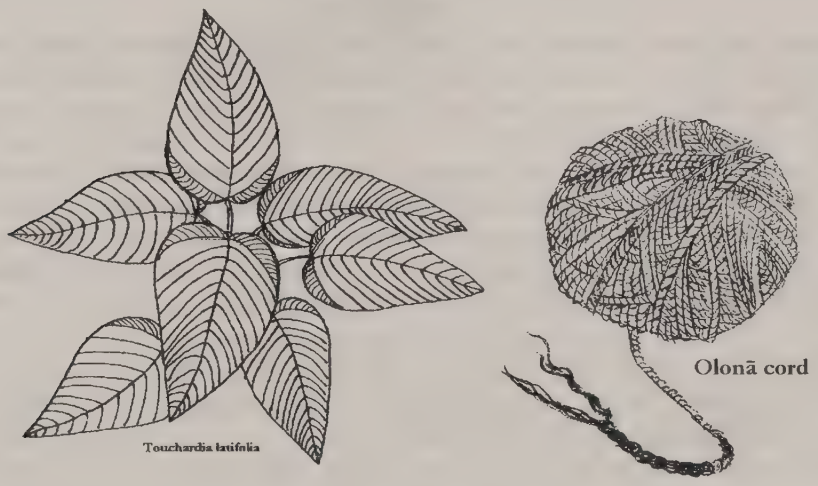
2.1.4 Pelagic Methods and Gear

Emory et al. (1959, 1969), Sinoto (1962), Newman (1970) and others have analyzed fish hooks in their archaeological and functional contexts. Goto (1986) provides analysis of the topic with reference to prehistoric ecological and social conditions in Hawaiʻi. Stylistic and functional variety abounds in the archaeological record (Goto 1986). Some hooks were composites, others were constructed from single materials such as mammalian bones, pearl, cowry shell, wood, and ivory. The dimensions and shape of

[6] See Kosaki (1954) and Meller (1985) for extended discussion of kuleana in the shoreline and ocean zones around Hawaiʻi.

certain hooks and their occurrence in the archaeological record with pelagic fish bones indicates specialization of fishing for pelagic species (Kirch 1985).

Abbott's (1992) work with plant materials and her review of historical sources relating to use of native plants reveals that olonā (*Touchardia latifolia*) was a highly functional and favored material for aho or fishing line. The relationship between aho makers and fishermen was important in the ahupua'a system, as line-making was labor intensive and fishing was highly specialized (Kamakau 1976).



Goto (1986) reviews Kahā'ulelio's description of the ancient aku fishery. Nets were sometimes used for aku, but trolling with lures attached to handlines was favored. Note that poles were used in some pelagic fisheries, but in all cases the lines were retrieved by hand. While pelagic fish such as 'ahi, billfish, ono, and mahimahi were pursued and consumed on occasion, the relative lack of their remains in the archaeological record and the predominance of aku bones suggests that aku was a principal target. Pursuit of aku reportedly involved certain conditions and indicators.

Kahā'ulelio (1902) mentioned that fishermen would set out to catch aku only when the sea was calm and smooth enough to see schools of nehu and other fishes. These small fishes are eaten by aku and therefore they are the indicators of the presence of a school of aku around them. The location of bird flocks was also a good indicator of aku (Scobie 1949).

As is the case today, fishermen in old Hawai'i sometimes pursued tuna using palu 'ahi methods while drifting or anchored above specific underwater features. These methods included the drop stone technique, wherein palu (shredded or mashed bait), leader, baited hook, and flat-sided stone were packaged and tied with a special knot. Once above the desired location, the package was lowered to the appropriate depth and the line was pulled to free the knot. The fisherman made ready for a strike as the palu and baited hook unraveled and the stone dropped off into the abyss.

2.1.5 Fishing Vessels

Efficient hooks and strong cordage were critical to fishermen in ancient Hawai'i. But the fishermen could not reach the deep-sea fishing grounds without a vessel. This was

the wa‘a, or outrigger canoe, made from the strong, durable, and buoyant koa (*Acacia koa*). Holmes (1993) cites Hawai‘i archaeologist Robert Hommon (1976), who asserts that most canoes were used for one kind of fishing or another. Hommon (personal communication, 2000) estimates there were as many 12,000 canoes in the Hawaiian Islands at the peak of their use. Kahā‘ulelio (1902) relates that different types of canoes were used for different kinds of fishing. Those used for aku were called ho‘omo and those that carried numerous paddlers were called panipani. Corney (1896) observed canoe-based aku fishing in the late 19th century and described the process as follows.

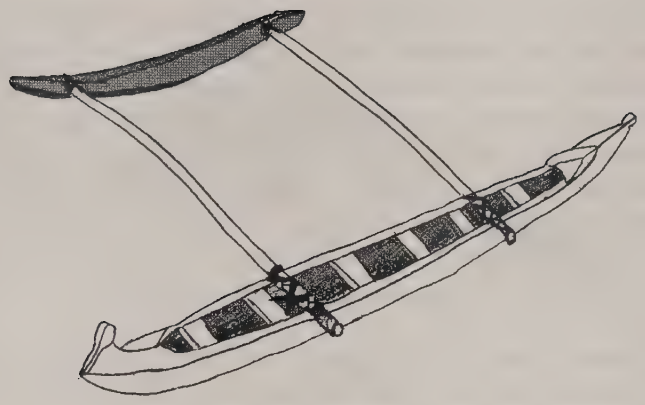
A canoe that pulls seven paddles goes to sea with two good fishermen (besides the paddlers), each with a stout bamboo, about 20 feet long, and a strong line made from the oorana [olonā]... the line is about three-quarters of the length of the pole, and has a pearl hook made fast to it. The canoe is then paddled very swiftly with the hooks touching the surface of the water, one at each side, the fisherman holding the rod steady against their thigh, and the lower end resting on the bottom of the canoe; they steady the pole with one hand, and, with the other keep throwing water on the hook [ostensibly stirring up the palu and imitating the effect of surface feeding], and when their prey gets hooked, by lifting the pole upright the fish swings in, and is caught under the left arm and secured. In this manner they will take 40 to 50 in the course of a few hours.

Sail power was used when possible, but when the wind was calm the power of paddlers was needed. Sometimes special double canoes with malau (baitwells) would be used, and nehu (Hawaiian anchovy; *Stolephorus purpureus*) or ‘iao (silversides; *Pranesus insularum*) would be added to the water to stimulate feeding behavior. Kahā‘ulelio notes that when malau canoes were being used, single canoes could not come close or would suffer the penalty of gear confiscation. The author states that “his father and many others had given up on malau fishing around 1848, since it involved too much work” (as reported in Holmes 1993), perhaps indicating that the social system that supported communal fishing operations in that region in years past was beginning to falter.

Kamakau (1976) provides a similar description, but also discusses the use of small lures trolled behind canoes in the manner of modern tolling vessels. He notes that this kind of aku fishing was undertaken by chiefs and rulers (who, in keeping with their status, may have fished more than paddled), and offers a detailed description of the red cowry aku trolling lure.

At the base of the pā there is a ridge, and through this was a hole drilled as a foundation for the cord of the snood, ka‘ā. The cord ran from the hole to the edge of the hook that was fastened to the tip of the shank lure, pā. The hook was made of human or dog bone, filed smooth and curved nicely. Pig bristles crossed the base of the hook where it joined onto the tip of the shank so that the hook would not fall over. The bristles ruffled the water behind the lure as those on the canoe paddled in unison, and the aku mistook the lure for an ‘iao or other small fish and crowded around to seize the pā hī aku.

Yellowfin and other large tunas were also pursued from canoes. Hosaka (1944) states that the Hawaiians named yellowfin ‘*ahi* (fire), “because it pulled the line over the side of the outrigger canoe so fast that the wood smoked as a result of the friction.”



2.1.6 Increasing Social Complexity

Isabella Abbott (personal communication, 1999) asserts that because relatively few persons lived in any one ahupua'a in very ancient times and because other food resources were plentiful, the need to pursue fish in the deep sea was probably not as pressing as in later eras. Goto (1986) suggests that in the early years of settlement, the production and distribution of food and other goods was likely based on kin relations. But as the ali'i set themselves apart from the rest of the population, surplus economies were developed. The author asserts that ali'i probably began to require increased harvest of pelagic species as part of a developing socioeconomic system in which such fish were highly valued (Goto 1986).

Pelagic fishing in ancient Hawai'i was an organized venture, and Kamakau (1976) describes the participation of a select guild of experts whose knowledge of the deep-sea and its resources would maximize the likelihood of success. Oliver (2002) discusses such specialization as a common aspect of Polynesian societies in general. Indeed, in ancient Hawai'i, the lawai'a haku was differentiated from lawai'a 'ili'ili or assistant fishermen (Kamakau 1976), indicative of a hierarchy of skill, experience, and related status.

The expert fisherman was accorded high status in ancient Hawaiian society. He knew best how to judge weather and sea states and signs indicating the presence of fish. He was well-versed in navigational skills and knew how to manage the interaction of fellow fishermen. Fishing knowledge was transmitted to chosen pupils (Kamakau 1976). At sea, communication between fishing canoes enabled a coordinated operation. Under the direction of the lawai'a haku, the fishermen signaled to each other by waving their arms or bamboo poles (Titcomb 1972). According to Beckley (1883), fishing canoes would sometimes travel great distances to fish; distant mountain tops and other landmarks were used to triangulate position above favored grounds.

Kaaiai (2008) asserts that Hawaiian society was task-oriented and specific duties were assigned to males or to females. Although wahine (women) were not part of the actual act of deep-sea fishing in ancient times, they did participate in certain preparatory activities, in the processing of fish, and as mentioned above, in various shoreline gathering activities (Titcomb 1972).

2.1.7 Offerings, Kapus, and Management of Resources

Titcomb (1972) asserts that the lawai'a haku possessed functional knowledge of the sea and fishing, but was also adept at interpreting dreams and omens and he maintained a

good relationship with the gods. Abbott (personal communication, 1999) relates her understanding that ancient Hawaiians offered much prayer and conciliation to Kāne and other gods of the sea prior to the deep-sea fishing trip. Kahā'ulelio (2006) states that fishermen observed strict kapus (rules and restrictions) before entering the ocean, such as avoidance of certain foods, conversations, and social contacts. Fishing, and especially fishing in the deep sea for aku, appears to have involved both a spiritual dimension and ongoing communal involvement. Thus, a successful trip led to an offering of appreciation to the gods; this was followed by proper distribution of the fish among those involved.[7] Kamakau (1976) expressed this process as follows:

He (the master fisherman) cast down the fish for the male 'aumakua (family god) and for the female 'aumakua, and then returned to give the fish to the canoe men, to those who had done the chumming, and to those who had done the actual fishing. A portion went to the owner of the fine-mesh nets, nae puhi, that had been used to catch bait and to those who had driven the bait fish into the nets. The rest was for the head fisherman or for the land holder, if it had been the land holder's expedition.

Goto argues that because aku bones are sometimes found in association with inland religious sites, the fish had probably begun to be valued as an important element of ritualized offerings to the gods. He also suggests that the seasonal nature of aku operations and associated rituals and patterns of consumption contributed to the ordering of ancient Hawaiian society.

The ancients undoubtedly experienced periodic shortages of pelagic fish. This is indicated by contemporary patterns of availability and by historic sources such as Newmann (1970), who notes that "not only is aku unpredictable in fishing, it is a seasonal resource, for aku migrations arrive primarily in the summer months in Hawai'i." The author discusses the beginning of the aku season as corresponding with the end of the annual Makahiki festival.[8] Fishing for aku was prohibited from October to January, during which time 'ōpelu was landed. Similarly, Titcomb (1972) reports on Mary Kawena Pukui's description of the appropriate timing of fishing activities along Ka'ū District on Hawai'i Island, as she learned it from her elders and by extension from persons residing in the region long ago: "there was never a time when all fishing was tabu [sic]... when inshore fishing [for 'ōpelu, for instance] was tabu, deep-sea fishing [for aku or 'ahi] was permitted and vice-versa" (cf. Handy and Pukui 1972).

Fishing for 'ahi (yellowfin tuna) was also subject to regulation. Iverson et al. (1990) cite Sahlins (1989) who asserts 'ahi fishing "appears to have been an integral part of a sacred chiefly rite associated with the Makahiki... ritual 'ahi fishing would have begun around the middle of December and continued until the end of the month when a five day prohibition on fishing began."

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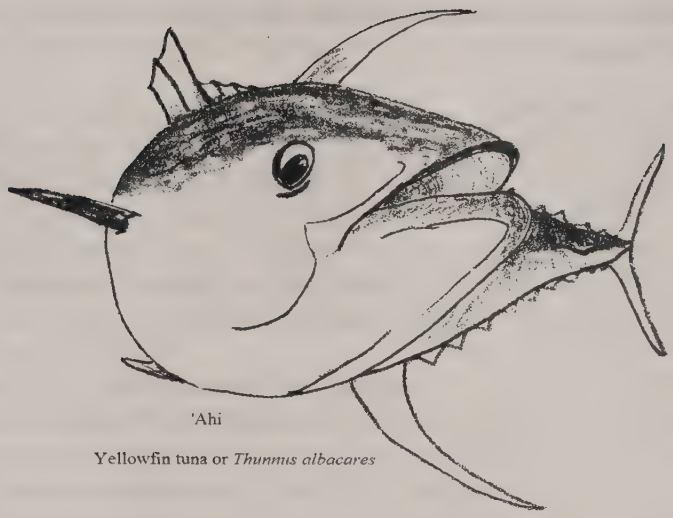
[7] Glazier (2007) repeatedly observed similar spiritually-motivated actions and communal behavior in Native Hawaiian fishing settings during the mid- and late-1990s.

[8] This was an ancient festival beginning around the middle of October and lasting as long as four months during which athletic and religious events were held, and a taboo on warfare was maintained (Pukui and Elbert 1986).



'Ahi

Yellowfin tuna or *Thunnus albacares*

Despite the fact that the timing of fisheries in old Hawai'i was highly regulated, it is difficult to determine through review of available literature whether the underlying rationale was primarily political, religious, or sociocultural in nature and/or whether such restrictions were part of a formal system of resource management as conceived of today. But it is logical to assume that kapus were implemented in part to conserve marine resources for the purpose of future consumption. Kapus obviously had the effect of conserving populations of certain species, especially localized stocks that were otherwise highly susceptible to sustained fishing pressure. Moreover, the konohiki was a keen observer of local ecological conditions and marine resources, and it is probable that inter-generational knowledge of such conditions and resources included an understanding of the ecological effects of fishing. But whether early Hawaiians possessed a clear understanding of the population-level effects of fishing on pelagic species cannot readily be determined through review of the literature.

2.1.8 Regarding the Dietary Value of Aku

Many species of fish were caught and consumed in ancient Hawai'i but aku was a particularly important food. Aku was eaten fresh and/or preserved with salt. The fish was an important trade item, and an important food item for the ali'i (Goto 1986). Goto reports that aku has 129 calories per edible part, totaling 839 calories per kilo gross weight. At 25.8 grams of protein per 100 edible grams of meat, aku provided the highest percentage of fish-derived protein then available to Hawaiians. The fish therefore provided more protein than wild boar, the meat of which yields roughly 17.5 grams of protein per 100 edible grams. Aku is also an excellent source of vitamin E, and its eyes and organs are rich in minerals; there was a strong custom of consuming these (Titcomb 1953). Seafood and aku, especially, was not merely supplementary to the Hawaiian diet but rather an essential component, balanced by roots crops such as kalo (taro), tubers, limu (seaweed), 'ulu (breadfruit), and other foods (Goto 1986). The dietary importance of aku and its seasonal abundance may partly explain its apparent religious importance and the commonality of its pursuit and use by Native Hawaiians over the centuries.

2.2 Continuation and Change Approaching and Entering the 20th Century

2.2.1 Decline of the Ahupua'a

Haoles (foreigners) brought many changes to Hawai'i during the 18th and 19th centuries. For instance, Hawaiians had little capacity to resist the effects of influenza, measles, and smallpox, and the transmission of these viruses from newly-arriving Europeans to the Hawaiians led to rapid decline in the size and well-being of the indigenous population. Introduction of the cash economy, pressure to accept Christianity, and the arrival of new material items were also associated with profound social and cultural change in the islands.

A more centralized and less place-specific system of laws, and of rules regarding use of natural resources, were enacted when the Kingdom of Hawai'i was established under King Kamehameha I in 1810. Eventually, as people living in ahupua'a and mokus (districts) became relatively less politically autonomous, the konohiki commanded less control over the land and sea (Titcomb 1972). This situation was furthered during the Great Mahele (ca. 1850), when the concept of private ownership of land was put into practice. This involved the reorganization of land holdings via the institution of fee simple rights, which allowed haoles to purchase land, thereby dispossessing many thousands of Hawaiians from their ancestral ahupua'a. By the end of the nineteenth century, Hawaiian society had been reordered in a way that essentially dismantled fully functional ahupua'a throughout most of Hawai'i.

2.2.2 Persistence among Native Hawaiian Fishermen

Hawaiians continued to fish during and after the Great Mahele, and as the new century approached, new materials were sometimes adapted for use in the present. As Scobie (1949) notes "many of the changes were substitutions of materials in old forms... spears were tipped with iron, metal hooks were fastened into the cowrie shell by molten lead, floats might be of cork and sinkers of iron or lead... new methods came with new fishermen." In some areas, fishhooks were made from metal wire and nails.[9] But significantly, Scobie (1949) indicates a tendency toward self-reliance among Hawaiians, noting that "[many] still preferred the fishhooks they made themselves rather than those that could be bought."

Old methods and new materials apparently were sufficient to contribute significant amounts of seafood to populations of Japanese, Chinese, and Filipino plantation workers and others living in Hawai'i. Schug (2001) cites Cobb (1905) to note that the first regular market for the sale of fish was established in Honolulu in 1851, and that Native Hawaiian fishing operations were the principal source of seafood. Scobie (1949) examines U.S. Commission of Fish and Fisheries statistics to report that of the 2,345 persons who sold fish in Hawai'i in 1901, 1,571 were Hawaiians, 485 were Japanese immigrants, and 238 were Chinese immigrants. These figures shifted rapidly in subsequent decades, as some immigrant plantation workers, especially those from Japan, began to compete with Native

[9] For example, a nail that had been fashioned into a fishhook was found in 1998 during archaeological investigation at Kaniakapupu near Nu'uanu Pali on O'ahu. This was the summer residence of King Kamehameha III during the 1850s.

Hawaiian canoe fishermen. Some such persons had come to Hawai'i with the specific intention of fishing on a commercial basis and a few were supported with the capital to do so (Schug 2001).

The volume of landings by small-scale Native Hawaiian fishing operations was eventually superseded by that of Japanese immigrants. This may have occurred in part because many Hawaiians remained dedicated to a traditional approach to fishing. One change that impacted fishing operations was the invention in 1907 of the first vertical crankshaft outboard motor by Ole Evinrude. These were mass-produced and available for use on small-boats in Hawai'i by about 1910. However, many Hawaiian fishermen preferred the relative silence of the paddled canoe to the noisy outboards (Abbott, personal communication, 1999).

There was little capital available in Hawaiian communities during this period, and there are clear indications of basic economic challenges in fishing-oriented households. For instance, in discussing her childhood days in the 1920s, Abbott (personal communication, 1999) recalled that unless olonā had been saved from decades past, other materials were used for handlines. Her uncle sometimes used lines made from coconut fiber, but more typically he used butcher string.

There are gaps in the written and statistical historical record which preclude a continuing account of Native Hawaiian handline fisheries in the years following the rise of the Japanese aku fleet and predominance of the sampan. It seems most authors living through that period (e.g., Scobie 1949, Handy and Pukui 1972; Titcomb 1972) were focused on recalling the distant past rather than recording the events and status of the present, which itself would eventually become of interest to students of fishing history in Hawai'i. It should be noted, however, that many historical accounts of fishing derive at least partly from the memory of informants then living, suggesting that certain fishing methods and traditions were lingering into the 20th century.

There undoubtedly was some continuity in use of outrigger canoes, old-style line and lures, and fishing methods, but data are sparse. Shomura (1987) notes, for instance, that landings data provide no valid clues to the scope of the subsistence or recreation-oriented small-vessel fisheries, since only commercial landings were reported between 1900 and 1986. Of note, there is some indication that the status of certain fish populations had declined by the turn of the century. Scobie (1949) and Titcomb (1972) suggest that this was related in part to diminishing localized control of fishing activity by the konihiki.

Although most Native Hawaiian persons who would be able to speak empirically of the pre-World War era have passed on, Maly and Maly's (2003) work with expert fishermen and elders around the islands provides evidence that Native Hawaiian fishing traditions and ecological knowledge continued to evolve into the early 20th century, even amidst the hegemonic tendencies and capitalist practices of the haoles. The work includes detailed accounts of many historical fishing practices—so detailed, in fact, that there may be some risk to local ecosystems should contemporary fishers re-adopt highly efficient methods of old without the framework of restrictions formerly associated with their use.

Modern materials eventually replaced the old even in the more remote areas around the Islands where traditions tended to linger in what McGregor (2007) refers to as kīpuka (pockets of traditional culture). For instance, Holmes (1993) notes that by 1940, the wa'a pā (three board canoe) had largely replaced the traditional koa dugout in most villages

along the Kona Coast of Hawai'i Island. The three-board canoe resembled the traditional dugout outriggers, even in the manner of its lashings. But it also utilized non-traditional features such as steel and, later, aluminum pipe for 'iako (booms), metal plates and screws, and outboard engines. The vessel remained a commonly used craft at Ho'okena and Pu'uhonua o Hōnaunau on Hawai'i Island as late as the 1990s, and it continues to be used along the Kona Coast today. Palu 'ahi fishing methods also continue to be used by Native Hawaiians and other local residents around the islands.

2.3 Japanese Immigrants and the Advent of Ika-Shibi Fishing Around Hawai'i Island

2.3.1 Introduction

During the first years of the 20th century, Japanese immigrants who had come to work in Hawaii's burgeoning sugar industry (United Japanese Society of Hawai'i 1971) increasingly took to the sea to fish. Kimura (1988) relates this to the expiration of individual labor contracts on the plantations. With their days in the fields at an end, many issei applied their own knowledge of fishing and the sea to deep-sea fishing in Hawai'i. Boats were designed in the manner of the Asian sampan. Initially using sail power, many issei eventually adopted gas engines.

2.3.2 Into the Twentieth Century: The Early Sampan Fleet

Gorokichi Nakasuji brought the first sampan design to Hawai'i in 1899, with great success to follow (Tomita 1940). Kimura (1988) describes Nakasuji's growing prominence, and tensions resulting from changes in fisheries that had long been the sole domain of Native Hawaiians.

Gorokichi [Nakasuji] built a boat... especially constructed and equipped to catch tuna in deep-sea waters. His arrival with this boat in 1899 resulted in a phenomenal change in the fishing industry in Hawaii... When the Japanese began deep-sea fishing, the quantity and variety of the catch increased, resulting in a sharp drop in the price of fish—a welcome change for consumers, but a threat to Hawaiian fishermen that caused bitter feelings.

Konishi (1930) also asserts that the Hawaiians resented Nakasuji's commercial efficiency, and that they threatened to kill him on the high seas. They did not, however, and an era during which the sampan fleet dominated Hawaii's commercial fisheries had begun. It is significant that macro-social conditions were changing in a challenging way for Native Hawaiians at this time, and in a way that was leading to new opportunities for enterprising immigrants. Early landings data (Cobb 1905) make clear that, as early as 1900, Japanese immigrants were succeeding in their use of deep-sea handline gear for bottom species and that similar levels of success in use of pole-and-line gear for aku would soon follow.

Commercial fishing on Hawai'i Island was enabled in part by the opening of Suisan Kabushiki Kaisha Ltd. (Suisan) in 1907, a company of Waiākea fishermen and buyers that later became a public auction house and, a century later, a private distributor once again. Commercial fishing opportunities were furthered on O'ahu, when the F.W. Macfarlane tuna cannery opened in 1917, later becoming Hawaiian Tuna Packers. The aku fishery (see Boggs and Kikkawa 1993), conducted from the aft deck of elongated

sampans, and the offshore longline fishery, nascent in 1917, were the primary sources of seafood during this general period (Schug 2001). The aku fishery continued to be highly productive for many years, as facilitated by the Hawaiian Tuna Packers cannery until its closure in 1984 (Pooley 1993).

2.3.3 The Origins of Ika-Shibi Fishing

Many immigrants came to Hawai'i Island from Okinawa Prefecture where fishing was an important aspect of daily life. At some point during the 1920s, fishermen originally hailing from such regions in Japan developed a nighttime fishery for squid in and around Hilo Bay. But it was often the case that the ika was taken by predators as they were being pulled toward the surface. The fishermen subsequently set out to catch the apparent culprit—shibi (yellowfin tuna). Yuen (1979) describes the situation:

Immigrants from Okinawa are believed to have started the [ika-shibi] fishery. They went out at night to catch squid as they had done in Okinawa. Occasionally something large would strike and snap their lines. Upon checking with the native Hawaiians they learned that the strikes were probably made by large tuna. They subsequently equipped themselves to catch the tuna.

The immigrants refined their methods over time, using handlines, squid-baited hooks, and a source of light to help attract baitfish, squid, and shibi. Suisan provided a venue for sale and distribution of the shibi. A new commercial tuna handline fishery was thereby initiated in the Islands.

Yuen (1979) relates that while the earliest ika-shibi vessels were sail-powered, as many as 40 motorized vessels became involved in the fishery in the 1930s. Of note, it appears that problems associated with spoiling were common during this early period, and these apparently continued until ice and brine were used on a more consistent basis later in the century:

... because the boats were too small to have the fish on board and did not carry ice to chill the catch, these tunas were towed alongside the boat on the way to port. Consequently, the [fish caught with ika-shibi gear] had a reputation [during the early days] of poor quality and could not compete on the market with tuna caught on longlines (Yuen 1979).

2.3.4 World War II

Local Japanese fishermen were denied access to the ocean during World War II, and many boats were confiscated. Schug (2001) reports that at least six such fishermen were killed at sea by U.S. soldiers who believed they conspired with enemy forces during the attack of Pearl Harbor.

There is some indication that fish populations, which ostensibly had diminished by the early 20th century, rebounded when fishing restrictions were established for security reasons during World War II (Markrich 1994). But Nakayama (1987) asserts that many fishermen of Japanese ancestry did not return to the fishing industry when restrictions were relaxed. Some found profitable work in ship building firms, which prospered after the war.

2.4 Hawaii's Small-Boat Fisheries in the Post-War Years

2.4.1 Technological Change and Population Growth

Many sampans and other fishing vessels were reinstated at war's end. Many of the larger sampans were used for commercial fishing, typically for aku. Some of the smaller sampans were used by local Japanese 'ohana to fish for food with relatively little operating cost (J. Uchiyama, personal communications, 1999). Native Hawaiians continued to use canoes and other small craft to fish both commercially and for food.

Yuen (1979) reports that at the end of the war three or four captains equipped their boats with ika-shibi gear and ice boxes and began fishing around Hilo once again. The population of Hawai'i Island just after the war was about 60,000 persons.

The post-War era was a period of growth for small-boat fleets around the Hawaiian Islands. Rizzuto (1977) describes the growth of fleets on the Kona side of Hawai'i Island, noting that "by 1957 the Kona [charter] fleet had grown to seven vessels" and that "the simultaneous development of [relatively] reliable outboard motors meant that the offshore grounds became the playground of marauding bands of 'mosquitoes' like the Kona Mauka Trollers and Kawaihae Trolling Club, ready to put their stingers into any big fish willing to fight."

Since its inception in 1952, the United Fishing Agency has played a central role in the development of commercial fisheries on O'ahu (and to a lesser extent fisheries conducted from the neighbor islands). The firm continues to function as a wholesale seafood dealer and auction house, facilitating the sale and distribution of fish landed by the aku, longline, charter, bottomfish, and small-boat pelagic fleets.

The small-boat fleets grew dramatically across the islands in conjunction with an improving post-war economy and improvements in hull and engine technologies. A field survey conducted in 1961 by Lubin, McGaughy and Associates indicated that nearly 5,300 privately owned small-boats, 83 charter vessels, and 532 commercial fishing boats were then active in the Hawaiian Islands. A Hawai'i Fish and Game Division study conducted between 1958 and 1961 confirms the increasing popularity of small-boat fishing at the time. Authors Hoffman and Yamauchi (1972) estimated that an annual average of 55,000 sport fishing trips were made along O'ahu's coastline during this period.

Introduction of the Johnson 55 horsepower outboard motor in 1968 revolutionized small-boat fishing by providing increased power, efficiency, and especially reliability at sea. Fiberglass hulls and marine communications technology also progressed and became more affordable during the 1960s and 70s.

This was also a time of economic expansion in the islands. Construction activity peaked at 8.2 percent of the Gross State Product in 1970 (Department of Business, Economic Development and Tourism 2000), with most new construction occurring on O'ahu. The sugar and pineapple industries still employed many workers on most of the islands at that time.

Evolution of sampan-style fishing vessels in Hawai'i

Relatively safe and efficient small fishing vessels thus became accessible during a time when many in Hawaii's working class could afford to buy and operate them. Law (n.d.) reports that as of 1970, some 7,689 "pleasure boats" were registered in the islands. Research Associates (1977) estimated that as many as 100,000 small-boat fishing trips were taken in the Hawaiian Islands in 1976.

One of the early ika-shibi operators then living on Hawai'i Island recalls that only four captains were active in the fishery during the early 1970s (D. Kalthoff, personal communication, 2003). But enhanced transshipment possibilities, increasing demand for tuna, and favorable market conditions enabled Hilo-based buyers to ship Big Island-landed tuna products to O'ahu and to various foreign markets (Yuen 1979). Increasing demand for seafood on O'ahu may be explained in terms of rapid population growth; the total population had grown from around 150,000 persons at the turn of the century to about 763,000 persons at the time of the 1980 Census.

2.4.2 The Ika-Shibi Fishery: 1973-1985

During the 1970s, government agencies were commonly advocating development of new fisheries and their economic benefits in the Pacific Islands. Thus, Yuen's (1979) discussion of the growing popularity of the ika-shibi fishery on the Big Island is, in part, a statement of encouragement for use of the highly effective technique elsewhere in Hawai'i. Nevertheless, ika-shibi fishing remained focused primarily around the Hilo and Kona coastlines of Hawai'i Island. Yuen reports that by 1976, at least 30 captains were using the ika-shibi method around Hilo, and that by 1977 an additional ten captains were using the method along the Kona Coast.

Hilo area landings of bigeye and 'ahi varied extensively during the reporting period (Table 2), as did its value; the combined ex-vessel value of all tunas was $131,000 in 1973 and $328,000 in 1975. With regard to the bigeye and yellowfin landings data presented here and throughout this report, it should be noted that juveniles of these species present similar morphological characteristics. This may compromise fully accurate reporting by the fishermen to some unknown extent.

Table 2. Hawai'i Island ika-shibi landings in pounds: 1973-1975 (per Suisan landings information)

Species	Year		
	1973	1974	1975
Bigeye	144,200	265,000	139,000
'Ahi	51,300	50,500	166,400
Tombo	800	400	35,500

Source: Yuen (1976)

With regard to the landed weights of bigeye tuna analyzed by Yuen (1976), only 12 percent of pieces landed in 1973 were over 100 pounds. Weights improved over the next two years; about 22 percent of pieces were over than 100 pounds in 1974 and about 28 percent were over than 100 pounds in 1975. Median weights ranged from about 69 to 73 pounds during the period. Reported median weights for 'ahi were highly variable: 48 pounds in 1973, 180 pounds in 1974, and 124 pounds in 1975. Yuen states that September and October were peak months for landing both species.

An important issue for harvesters and distributors of the day (once again) involved oxidation of tuna. Although the preventive qualities of ice and brine were increasingly well known, the tuna burn issue appears to have persisted in some quarters, with related tensions at the marketplace.

The burnt condition cannot be detected until the fish is dressed and the flesh exposed. Because tuna are transported whole to preserve their quality, the burnt condition is not detected until after transportation expenses have been incurred. The problem is compounded when the seller who must accept the distant buyer's judgment of quality begins to doubt the integrity of the buyer (Yuen 1978).

Yuen (1978) also provided context for understanding how the ika-shibi fishery functioned in social terms. For instance, he emphasized the value of understanding the timing and locations of the bite—suggestive of the critical importance of effective communication and transmission of knowledge between participants and generations of participants in this specialized fishery.

Vessels typical of the era at Wailua Ramp, late 1970s (Courtesy of Walter Ikehara)

Large ‘ahi at Suisan auction, late 1970s
(Courtesy of Walter Ikehara)

Map 1. Hawai'i Island and adjacent bathymetry

Ikehara (1981) subsequently re-examined the ika-shibi fishery under contract with the National Marine Fisheries Service, Honolulu Laboratory. He, too, recognized the productive and lucrative nature of the fishery and its potential for development in other parts of Hawai'i. Of significance to the current analysis, the author noted some of the challenges associated with interpretation of data regarding the ika-shibi fishery—challenges which continue to be addressed by state and federal agencies today.

Since there is no separate category for ika-shibi in the catch reports of the Division of Aquatic Resources... ika-shibi catch data are usually reported in the deep-sea handline category. Because the deep-sea handline category may also include catch data from the day handline and bottomfish handline fisheries, it is difficult to distinguish the ika-shibi catch. It is also possible that some of the ika-shibi catch may not be reported at all.

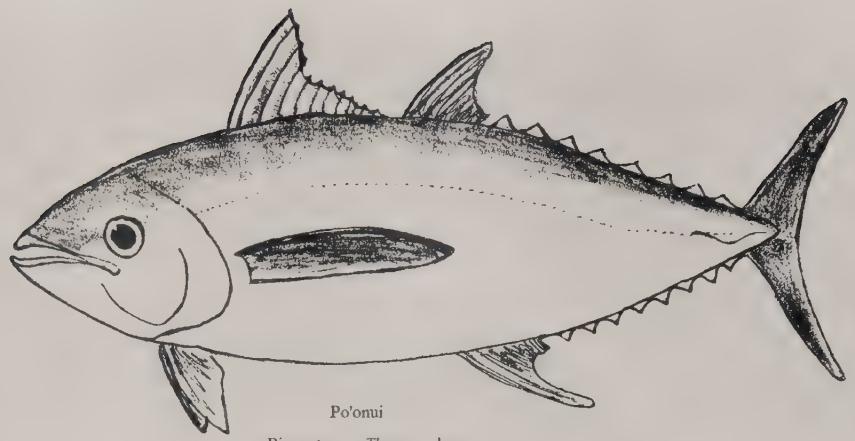
Ikehara's analysis of the Hawai'i Island ika-shibi fishery indicates further growth by 1980, with increasing participation from Pohoiki in Puna District and from various points of access along the Kona Coast. He reports that 233 fishermen used ika-shibi gear in 1980, with 175 using the method 15 times or less, and 55 using it more than 15 times that year (Ikehara 1981). He also discusses strong economic incentives to participate in the fishery, estimating average fishing-specific incomes of between $40,000 and $80,000 per year during the period, with highliners estimated to earn as much as $140,000 per annum. Total ex-vessel revenues were estimated to exceed $2.9 million in 1980.

Table 3. Reported ika-shibi landings by species: 1980

Species	Pounds	Pieces	Ex-Vessel Value $
'Ahi	814,871	21,110	2,618,945
Bigeye	29,266	819	108,611
Tombo	43, 645	1,837	71,374

Source: Ikehara (1981)

Bidders at Suisan Auction in Hilo, late 1970s (Courtesy of Walter Ikehara)



Po'onui

Bigeye tuna or *Thunnus obesus*

Of note at this juncture are assertions made by some elderly ika-shibi fishermen who were involved in the fishery in the 1970s. Some believe that establishment of the State's fish aggregating devices in 1980 disrupted traditional feeding and spawning patterns of bigeye tuna and 'ahi, while generally increasing small-boat fishing traffic on the water.

The ika-shibi fishery continued to grow, and significantly so by 1984. The State of Hawai'i, Division of Aquatic Resources (HDAR 1986) reports that about 125 captains were fishing ika-shibi gear on a full-time basis that year—a 46 percent increase above the level of participation reported by Ikehara (1981) for 1980. Again, most of this activity occurred along the Hilo side of the Big Island, and to a lesser extent along the Kona Coast. The HDAR (1986) study reports that an additional 45 captains were operating on a part-time basis around the Big Island that year, and that four full-time ika-shibi captains were operating from Kaua'i.

It is at this point (in 1986) that new problems were noted in the fishery. The HDAR authors assert that high rates of return had initially attracted many fishermen to engage in the ika-shibi fishery, but that participation had leveled off and catch rates and revenue had begun to decline—by over 49 percent since 1979 (HDAR 1986). It was reported that declining catch rates were first noticed during the year following Ikehara's 1981 report, and that some fishermen had been forced to drop out of the fishery as expenses started to exceed revenue.

With current expenses averaging $170 per night, fishermen say that six consecutive trips without catching 'ahi [or bigeye] will force them out of business because their line of credit for necessities such as fuel, ice, and bait will be exhausted. The decline is evident in reported catch rates between 1979 and 1983. The 1979 catch rate was reportedly 2 fish per hook per night (Yuen 1979), while the 1983 catch rate was 0.5 to 0.7 fish per hook per night... As catch rates declined, many found themselves unable to meet mortgage payments which resulted in increasing foreclosures on full-time ika-shibi boats (HDAR 1986).

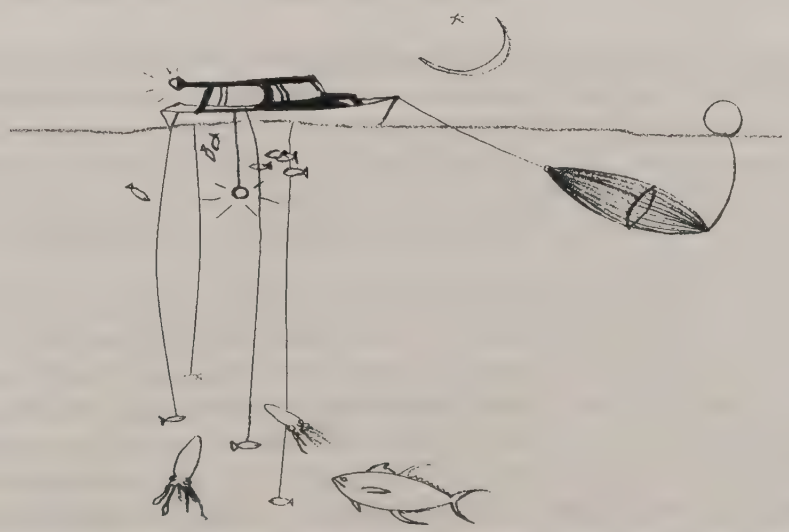
Inset A **The Ika-Shibi Technique**

Ika-shibi is a nighttime small-boat tuna fishery that was developed in the nearshore waters of Hawai'i Island during the second decade of the 20th century. Captain and crew (typically one or two) deploy a parachute-type sea anchor to keep the vessel in a relatively stable and slow drift, usually above or near favored drop-offs, such as the 600 and 1,000 fathom curves, and around ko'a, FADs, thermoclines, or other features. *Ika* is the Japanese word for squid and *shibi* is the Japanese word for tuna.

The summer months have been particularly productive for the ika-shibi fishery in years past, though some years involve a winter bite as well, often involving bigeye. Production and use of chum lines by cooperative captains is common. For many fishermen, lunar phase is an important determinant for timing the trip. Underwater 25-50 watt lamps and sometimes 25 watt above-water lamps running from a 12 volt power source attract baitfish and squid to the vessels. Fresh squid are the preferred bait, but 'ōpelu (mackerel scad) or frozen squid are used on occasion and may initiate a night's fishing until fresh squid are caught (Rodgers 1987). Some shibi fishermen interact with 'ōpelu net fishermen to acquire fish for use as *palu* (chum; in this fishery anchovies or sardines are often used). The palu is intermittently dispersed as an attractant in the water column during the course of the operation.

Three or four long braided polypropylene or nylon lines are equipped with 300 to 400 lb. test leaders, baited 14/0 to 16/0 (size 32 to 56) circle hooks, and lead-filled tubular weights. These are cleated at staggered depths for fishing between about 10 to 15 fathoms and sometimes deeper, depending on the targeted feature. A breakaway line, often made of cotton cord, alerts the fishermen by making a pinging sound on the rails of the vessel as it breaks just prior to hook up.

Once the hook is set, the fish is hauled to the boat by hand on the main line. Skill is needed to gauge the strength of the fish (or multiple fish) and to play them properly to avoid loss of fish (and/or line and leader). Strikes often occur in clusters, making for sporadic periods of intense activity on board. Fish are stunned with a bat, and terminated— usually with a stiff wire run through spine/brain cavity. Large fish are bled, gilled, and gutted; some operators head the fish. These actions and consistent use of ice and icy brine have reduced burn problems characteristic of historic ika-shibi operations. Much effort is now exerted to chill the fish adequately to meet market demands for high-quality fish, which is often used for sashimi.



The HDAR authors suggest that a number of problems underlie the decline, including and in addition to reduced availability of tuna and (ostensibly) related environmental factors.

The current depressed condition of the fishery may be attributed to several factors, including: 1) noticeable decline in availability of large tuna, which could be partly attributed to the "El Nino" phenomenon; 2) the financial burden on the fishery created by heavy capitalization in the face of declining catch rates; 3) difficulty in obtaining access to overseas markets by means of air freight and 4) a lack of quality control in the fishery partly the result of the tuna burn problem.

2.4.3 The Daytime Palu ʻAhi Fishery: World War II to 1985

Use of the fishing method called palu ʻahi does not as readily define a distinct fishery as does ika-shibi. First, palu ʻahi fishing actually involves several techniques, including drop stone, make dog (mah-kay dog), and variations thereof. Second, palu ʻahi fishing is both ancient and contemporary, but there is little information available with which to describe the interim. For instance, the commercial palu ʻahi fishery did not attract the early attention of the Division of Aquatic Resources as did the rapidly-expanding ika-shibi fishery, and thus there was no directed data collection effort until a distinct palu ʻahi gear category was added to the commercial catch reporting form in 1986. Even at that point, reporting of palu ʻahi fishing activity was sporadic and uncertain until about 2002.

The palu ʻahi form of fishing does indeed have a long history of use in Hawaiʻi, likely beginning long before Cook arrived there. Maly and Maly (2003) describe the basic mechanics of palu fishing methods based on readings of various historical accounts, including those of Beckley (1883), Kahāʻulelio (1902), and others:

Fishermen had many customs and devices. The lihi was one kind of hook; another was a baited hook; octopus palu or chum was the device used by some fishermen; released (hoʻoholo) live fish was the bait of others. A hook baited with flesh (paʻiʻo) was another bait. One kind of palu was handfuls of whole fish—ʻōpelu or akule or puhi kiʻi perhaps—pounded until soft, and wrapped in coconut cloth, aʻa niu, with a stone inside. This was let down to the bottom of the koʻa, and then shaken until the stone rolled out and the palu scattered... Those who understood the properties (mana) of good bait would come to shore with a good catch... (Maly and Maly 2003)

The modern techniques are similarly straightforward, as noted in Inset B. While there are few data sources available to help describe the extent of use of such methods over time, based on ongoing work with elderly fishermen, it can be surmised that the palu ʻahi method was used consistently in the 20th century by a relatively small number of Native Hawaiians who fished over various koʻa in remote areas along the Big Island. The method has been used more recently by a broader subset of local residents who recognize its simplicity and efficiency.

Lyman et al. (1984) assert that few fishermen practiced palu ʻahi techniques until the early 1970s, but that by 1979 some 100 or so were using the method. The increase undoubtedly relates both to the general increase in small fishing vessels around the Big Island, as previously discussed, and to the significant increase in the number of operators using ika-shibi methods at the time. Regarding the latter, it is clear from interviews with former participants that many operators staggered use of both nighttime ika-shibi and daytime palu ʻahi methods, and would occasionally use both methods during the course

of a single trip. As regards landings during 1979, the author provides some indication of approximate volume (one million pounds), but these figures are combined with ika-shibi landings— indicative of the ongoing difficulty of accurately assessing catch for any specific component of the handline fleet.

Native Hawaiians developed distinct kinds of palu and approaches for attracting different species. For instance, vegetable matter such as taro and pumpkin[10] was traditionally used to attract and train ʻōpelu at ʻōpelu koʻa along the Kona side of Hawaiʻi Island (Abbott 1999; Glazier 1999), and palu made from ʻōpelu was often used above ʻahi koʻa. Appropriate formulation and use of palu has long been of concern to Native Hawaiian fishermen, as indicated by Cobb (1905).

The natives are very expert in the preparation of palu, or baits, from various substances. In making these a small section of the sharp end of a cocoanut [sic] shell, about 1½ inches in height, and a small stick of wood are used, in the same manner as a mortar and pestle.

Knowledge and techniques associated with preparing to fish and fishing above ʻahi koʻa historically were and remain intricate and important aspects of handline fishing in Hawaiʻi. This is exemplified in an interview conducted between Kēpa Maly and a kupuna (knowledgeable and locally respected elderly person) who was deeply familiar with the topics of interest (Maly and Maly 2003). The Native Hawaiian discussant was born along the South Kona Coast in 1925. His description of the drop stone method makes clear the subtleties involved in fishing effectively with palu ʻahi methods and the historic importance of fishing knowledge in the lives of many Native Hawaiians and others residing in rural Hawaiʻi.

[The kupuna] discusses fishing for ʻahi, ʻōpelu, *and other fish; and the relationship of baits to the health of the* koʻa. *When young, [he had] never heard of "*make dog*" or other "*pilau*" [smelly] baits:*

KM: One of the things that has happened in your ʻāina *[land] out here, is that your folks* palu *[chum], when you* kaʻaʻai *[spread], it's* kalo *[taro],* palaʻai *[pumpkin]...?*

EK: Yes.

KM: Now people are coming in with...they started this thing called pilau, make dog, *chop-chop [use of shredded fish or meat as palu]. What is your thought about that in your folks'* ʻāina*?*

EK: [chuckling] When you talk about make dog *[chuckling], that's another thing. When I heard that, when I came back, "*make *dog!" I asked, "What's that?" Oh, they go out for* ʻahi. ʻAhi *fishing. And they talk about "*make *dog." "Yes, we put down our* make *dog in this and that." I never knew what that is. But it's not the* palu. *When we go out* ʻahi *fishing...Well to begin first with the old folks, the way they fished before they used* kēpau *[lead] and everything, it was all stone.*

KM: ʻAe.

EK: Even night time and everything, they go with stone. That what takes their things down, yeah?

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[10] Pumpkin was introduced by either Cook or Vancouver and thus could not have been used in pre-Contact times (Abbott 1999).

KM: Yes.

EK: You get your line, your hook, your bait, and how you coil your line, with your aho *[line] on top. That's how you're going down. Then you drop 'um down, you* huki *[turn] one, two times, you can feel that* pōhaku *[stone] rolling,* hemo *[loose]. And that is how you have to tie that with the bait on, or some you put the* palu *on top. That is how you tie (gesturing with hands), you get so many turns around, you tie, and you let it go. As soon as you (makes jerking motion with hand), one, two times, you can feel the stone roll and roll. As soon as it's clear, you know your hook and bait is out waiting for the fish, but you have to hold it, you have to feel 'um. Sometimes roll and roll and then you feel heavy one time, ah, the line went* pa'a *[stuck] with the hook, the stone never* hemo. *You got to bring 'um up.*

KM: Hmm, and deep some, yeah?

EK: Sometimes deep if you're going for 'ahi. *Shallow fishing not so bad, the small kinds of stones. But the* 'ahi, *you have to do that. So everything is on top, you* palu *and everything. You get your* 'ōpelu, *the whole* 'ōpelu, *you* kaha *[slice lengthwise] one side, the meat. You* kaha *right down and drop down, then you hook the head. Then the other half of that, you chop 'um, and then you put it on top of the* pōhaku. *You* wili *[wind] your leader with the* makau *[hook] . . you make 'um like a little coil and you put all your meat inside there. Then you let it go, and you* hemo, *and that's how you* palu.

And then later on, they started to use cloth, welu, *like the* 'ōpelu ka'a'ai. *[Even with] the* welu *they still use stone. So naturally, when you put your* palu *in side, you* wili *the* welu, *you just tie one time,* pau. *You let 'em go. And that way, the* palu *all* pa'a *[keeps together in one chunk]. But that way is good. Sometimes they say when some* 'ahi *fishermen go, and when they cut their chunks. You have to cut pieces not too small. You will, you make sure you* pa'a, *so the pieces stay* in.

But if you make kāpulu *[careless] when it's going down, then the* palu hemo *all over the place, and then the fish are running all around the place. And sometimes you're not catching because all the fish are concentrating on that area with the* palu *and you're not catching. But if you make good, as soon as you make the place, everybody the same place, all catching the fish. And that's when they came with the* welu, *the* ka'a'ai.

KM: 'Ae.

EK: You put the welu *and you wrap 'um. And you know* pa'a, *the meat doesn't* hemo *when you go down. That's how it started.*

But actually, I don't know if any of them know this, because before they had the welu, *only the* pōhaku. *You know the* noni *leaf [Indian mulberry or* Morida citrifolia*]?*

KM: 'Ae.

EK: You pick up the noni *leaf and then you wrap the* noni *leaf around that* pōhaku, *and then you* wili. *That way,* pa'a *all the meat inside there. And that was the idea that they wanted to* pa'a *that meat. Because once the fish run a certain depth, where the* 'ahi *running, you go over there, hit that, every time, everybody is putting in. Sometimes I go, we go. Morning time is a certain depth, afternoon time a certain depth. Certain kind of* 'ahi *run deep. So you have to know all of this.*

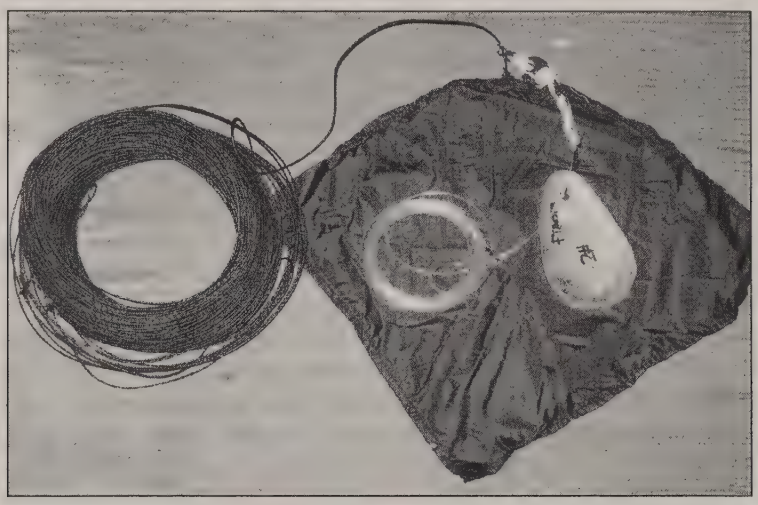
KM: Yes. Were you folks still using pā *[pearl-shell hook] or were you using metal?*

EK: The pā *is when you go* hī aku *[troll for aku].*

KM: So you use hook on your ʻahi.

EK: Makau, *the hook. That's what we used to do. Then when I came home, they started to use that "*make *dog." They get that rag and they put that lead, and then when they throw down and* hemo, *the* palu *bag is over there, and the lead is over there yet. Sometimes, if there's plenty* ʻahi *running, no* pilikia *[no problem] you use that. Good, no need worry about going to look for* pōhaku. *But sometimes, when the fish are not running, or really not biting so good, it's best to go with just the* pōhaku *and the bait and the line. If you get your line over there, and the* welu *is going like that [gestures, fluttering around], and the lead is hanging . . he no like see this thing hanging and flapping around. So you catch and you pull in yours. Unless the fish are really excited and running, they'll go with anything. So that's the kind of thing you have to do.*

[Excerpts from Maly and Maly, Volume II (2003)]



Contemporary *make dog* rig

2.4.4 Advent of the Cross Seamount and Weather Buoy Handline Fisheries

Wessel and Keating (1994) describe Cross Seamount as an 85-million-year-old Cretaceous guyot (a flat-topped mountain or seamount) that was carried to a point near the Hawaiian hot spot by plate tectonics. Geologic evidence indicates that the mountain was truncated at sea level about 3.2 million years ago; it is now about 400 meters below the surface. The feature is located at 18°40' N, 158°10' W, or about 160 nautical miles south of Honolulu.

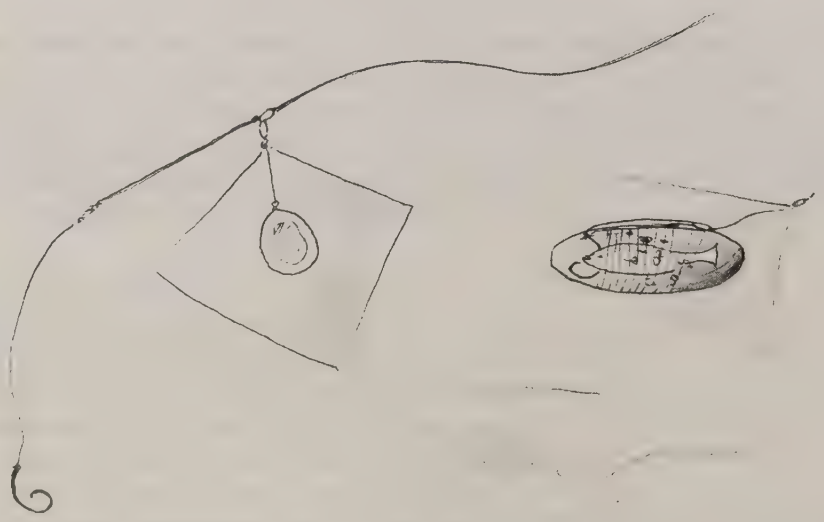
The behavior and trophic dynamics of tunas around seamounts in the Central Pacific are increasingly better understood (cf. Sibert et al. 2006), and it has been apparent for some time that, for large pelagic species, catch per unit effort tends to be higher around seamounts than in adjacent ocean areas (Fonteneau 1991). Holland and Grubbs (2007) discuss two general hypotheses about why this may be. First, seamounts may be associated with enhanced availability of food, and second, seamounts may function as aids to navigation for moving and migrating tuna. In the case of Cross Seamount, conduct of fisheries above the feature appears to have been further enhanced by suitable depth, and relatively close proximity to ports in Hawai'i.

Inset B **Palu ʻAhi Techniques**

Palu ʻahi is a tuna fishing method that was developed in the Pacific Islands over the millennia. In the Hawaiian language, "palu" refers to chopped and/or mashed bait. Historically, the bait material was wrapped around a smooth stone, covered with a leaf or placed in a cloth package and lowered to depth over a specific target, usually reef formations where ʻahi were known to congregate (ʻahi koʻa). In some cases, palu has been used to "train" pelagic and/or neritic-pelagic species to feed at such features in advance of their capture. The type of palu and its preparation were and remain critical in the traditional context. Although the palu ʻahi method is most common around the Big Island, it is also used elsewhere in the Hawaiian Islands. Some captains use parachutes to enable their vessels to drift slowly over the targeted feature; others do not. The palu ʻahi method is also called "bust bag" or "drop stone" in local vernacular.

In the case of the "drop stone technique, a hook baited with ʻōpelu is wrapped with leader and chopped ʻōpelu or other palu around a flat-sided beach cobble or similar stone. When the bait is lowered in a cloth or canvas bag to the proper depth, the mainline is jerked, releasing the double-curl slipknot that secures the package. The contents spill out, ideally incurring a feeding reaction by the tuna. The stone falls off onto the bottom as the palu is dispersed and the leader and hook uncoil. While this gear is fished in as little as 10 fathoms at nearshore koʻa and as deep as 80 fathoms farther offshore, depth of use can vary extensively, depending on the nature of the targeted feature. Appropriate depth of use may be determined by experimentation or by identifying the depth of large fish on a depth recorder. Some fishermen use palu to draw large fish close to the surface where gear such as bamboo poles or danglers may be used.

Make dog is similar to drop stone, and probably a natural evolution of the technique in that it allows the fisherman to retain the weight. It may have evolved in Japan or among Japanese immigrant fishermen in Hawaiʻi, as the phrase "make doggu" is also sometimes used, which in Japanese means "wrapped device." The method involves use of a flat, ovoid lead weight – the convex side of which is shaped to accommodate the ʻōpelu bait. The weight and bait are wrapped in a piece of cloth and lowered in a manner similar to drop stone. But in this case, the lead weight is tethered to the mainline and can thus be retrieved. Size 13/0 to 16/0 circle hooks are used in both drop stone and make dog techniques; constant and movement-sensitive upward pressure on the mainline is essential during retrieval.



Although it is quite possible that Hawaiians undertook fishing voyages to Cross Seamount in centuries past, this is not readily apparent in the ethnohistoric literature, nor is it clearly stated in known oral traditions. Discussions with elderly fishermen from Hawai'i Island indicate that Cross Seamount may have been fished on a commercial basis by a small group of Native Hawaiians prior to World War II. However, the small-boat commercial fishery at Cross Seamount was not consistently undertaken until the early 1970s. Early participants in that fishery report that the nearshore waters of the Big Island were then becoming increasingly crowded and that a diminishing number of large tuna were being landed, and for those with suitable vessels and fortitude, distant-water fishing at the seamount was an attractive alternative.

Small-boat fishing activity at Cross Seamount slowly increased during the 1970s as word of success gradually spread through a network of prospective fishermen. While only four to six operators reportedly fished the area through the 1980s, as many as 20 captains were regularly making the voyage when the fishery reached its peak level of participation in the mid-1990s. One source suggests that over 30 captains fished the seamount in 1993. Although vessels used in the handline fishery at Cross Seamount have tended to be in the 40-foot range (Hamilton and Huffman 1997), length of vessel has varied. For instance, a Kewalo-based captain regularly made the voyage in a 32-foot boat during the late 1990s, and another has long fished the area with a 60-foot vessel.

Cross Seamount has also been of sporadic interest to certain captains in the Kona-based charter fleet and the Hawai'i-based longline fleet. Captains in the longline fleet tend to pursue bigeye along the slopes of the seamount (Itano 2004). Fishing for monchong (*Taractichthys steindachneri* or Sickle pomfret) also occurs here.

Of note from a sociological perspective, some contentious interactions are known to have occurred at Cross Seamount during the early 1990s. Problems reportedly occurred when longline captains conducted shallow sets near the smaller vessels or, conversely, when small-boat captains fished in the vicinity of gear deployed by the larger longline vessels. Fishermen report that, in some cases, such close encounters led to entanglement of longline gear and handline vessel parachutes.

Representatives of the fleets reported additional problems during the early 1990s (and again later in the 90s). Handline fishermen working at Cross Seamount reported that buyers did not offer a fair market price for their tuna, and longline fishermen reported that handliners were landing too many juveniles. A group of handliners publicly recommended a longline exclusion zone, and longline representatives publicly suggested that commercial sale of tuna should involve a minimum size limit. Following a series of deliberations, an option involving limitation of new entry into the handline fishery was ultimately prioritized by the Council, and in 1992, a control date was established for the offshore handline fishery.[11]

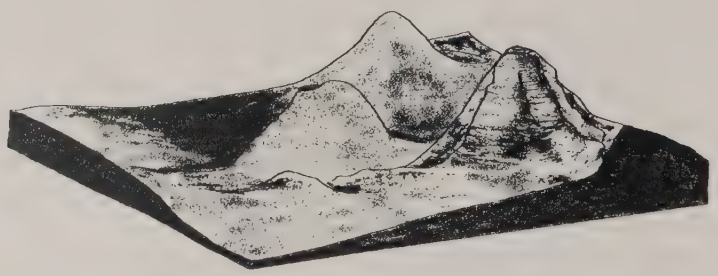
The full range of handline methods have typically been used at the seamount, including the drop stone and make dog techniques during the day, and methods similar to those used in the nearshore ika-shibi fishery during the nighttime hours. Fishing

[11] A control date can be used by fishery management entities to establish eligibility for future access to specific fisheries and, in some cases, to discourage speculative entry into an established or new fishery. In this case, a control date was set for July 1992. More recently, the Council established a general control date of June 2, 2005 for all Hawai'i non-longline commercial pelagic fisheries. This was established in response to stock assessments indicating that bigeye was subject to overfishing in the Pacific Basin.

strategies often take into consideration the appropriate time of day to drop lines, and the appropriate speed and direction of drift in localized current patterns. Locally caught squid or frozen ʻōpelu are often used for bait. Frozen anchovy, ʻōpelu, or other fish are typically used for palu. Most captains troll for pelagic species while heading to the grounds. Hydraulic line pullers are sometimes used to haul fish aboard.

A small number of handline captains and their crews also began to fish the offshore meteorological buoys after these were established by the NOAA National Weather Service in the early 1980s. These devices collect and record various climatologic data, including wind speed and direction, and direction and size of wind and ground swell—all of which are vitally important forms of information for small-boat captains navigating around the islands. Significantly, the buoys also tend to aggregate pelagic fish in the manner of the state-maintained FADs, and PFADs.

Captains have been reporting the capture of pelagic species from around buoy 51002 (Buoy Two) and buoy 51003 (Buoy Three) for many years now. These devices are located south-southeast of Cross Seamount. Limited handline activity has also occurred at buoy 51004 during certain years (Buoy Four). Although buoy 51001 (Buoy One), located northwest of Kauaʻi, may have been fished by a small number of captains during certain years, this is not reflected in the landings data. It should be noted that although the weather buoys have been important to certain captains over the years, the greatest proportion of offshore handline fishing has occurred at Cross Seamount. Additional description of the Hawaiʻi-based far offshore handline fisheries is provided in Section 3 of this report.



Rendering of Cross Seamount based on sidescan sonar imagery

3. RECENT TRENDS IN HAWAIʻI PELAGIC HANDLINE FISHERIES

This section of the report describes Hawaii's commercial handline fisheries as these have evolved during more recent years, 1985 to 2008. The description is focused on basic patterns of participation and production in each of the previously discussed fisheries, as indicated by HDAR license and landings data, and by discussions with seasoned participants in those fisheries. Explanation of trends is based on field observations and interview data. Each of these sources of information is also used to describe and explain trends regarding the recent innovative development and use of PFADs and vertical short-longline methods.

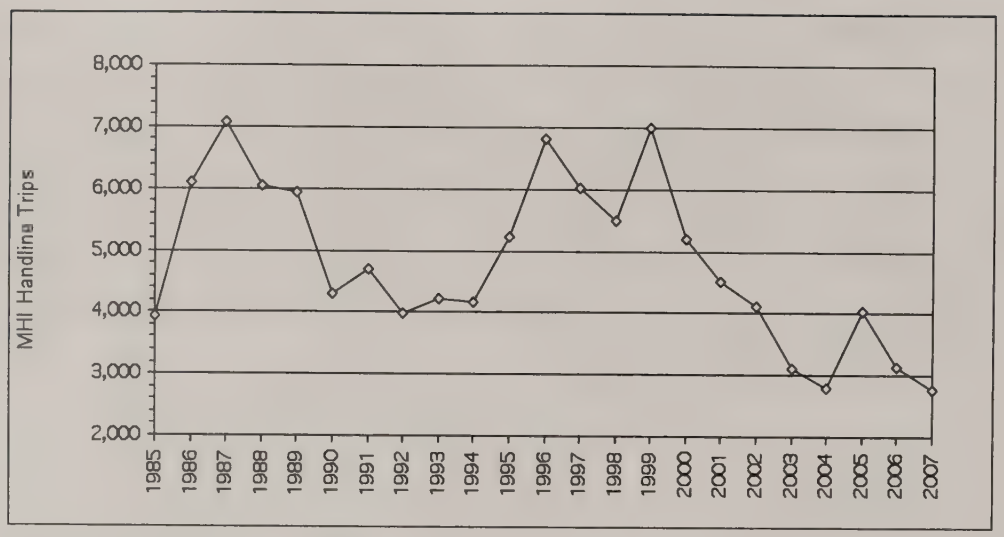
3.1 Overview

Although landings data have been collected and maintained by agencies in Hawai'i since 1948, HDAR systematized its mandatory small-boat commercial catch reporting system in 1985, which made it easier to generate and maintain information about specific kinds of commercial handline activity. State and federal law continues to require that all captains who sell any portion of their catch must complete and submit commercial trip reports on a monthly basis. Seafood dealers must also submit forms detailing purchase and sales transactions. This PFRP report provides analysis of aggregated data primarily from HDAR tuna handline reporting forms. These require: (1) name of fisherman; (2) commercial fishing license number; (3) vessel registration number; (4) U.S. Coast Guard certification number; (5) trip start and end date; (6) port of departure; (7) day, area, and specific fishing methods used; (8) hours per method; (9) number of fishing lines used; (10) number and total pounds of harvested bigeye tuna between (a) 1 and 40 pounds and (b) over 40 pounds; (11) number and total pounds of harvested yellowfin between (a) 1 and 40 pounds, and (b) over 40 pounds; and (12) number and total pounds of each additional species landed, lost, and released.

It should be noted that, as is the case in other regions in the U.S., the license and landings data system in Hawai'i has necessitated ongoing administrative adjustments and work with fishermen to improve data reliability and validity. For instance, R. Kokubun (personal communication, 2006) notes that for purposes of reporting and analysis prior to 2002, ika-shibi and palu 'ahi catch data were not as clearly and consistently discernible as distinct components of the handline fishery as they were thereafter. Until 2002, many fishermen would report catch in the generalized offshore handline category without necessarily indicating the specific type of gears that were used during a given trip. This was problematic for analysis because handline fishermen often use numerous types of gear during the course of a given trip. Modifications to the reporting form led to more precise reporting and analysis of handline data beginning in 2002.

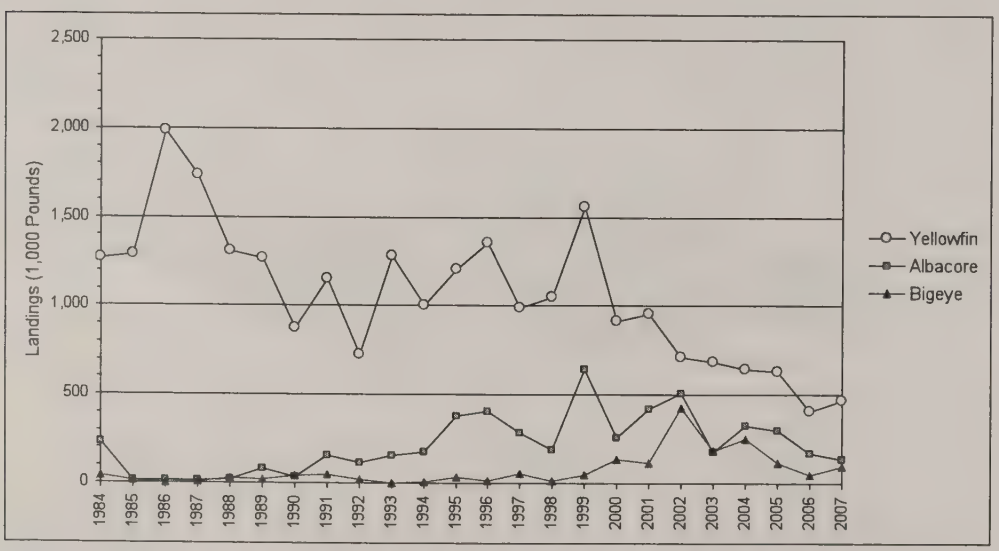
Although the extent of underreported or misreported landings is not well-understood in Hawai'i or elsewhere, any analysis of landings data should be qualified by acknowledgement that an uncertain volume of catch goes unreported, and that information provided on forms that are submitted is not necessarily entirely accurate. For instance, because bigeye and 'ahi present similar morphological characteristics as juveniles, the accuracy of data regarding small pieces has long been somewhat uncertain. Observation suggests that reporting problems are more significant among some part-time commercial operators than among most high profile highliners.

The ongoing efforts of data managers at HDAR and NOAA Fisheries have led to improvements in the reliability and validity of fisheries data in Hawai'i, but certain challenges remain; such is the nature of fisheries data everywhere. Based on the best available data, and reporting problems notwithstanding, important trends are discernible in figures for participation and production in Hawaii's commercial handline fisheries. As indicated in Figures 1 and 2, effort and landings have significantly diminished since the year 2000, in a manner similar to a trend occurring after about 1987.



Source: Hawai'i Division of Aquatic Resources

Figure 1. Trend of overall effort in the MHI handline fisheries: 1985-2007



Source: Hawai'i Division of Aquatic Resources

Figure 2. MHI handline fisheries landings: 1985-2007

Of particular note in the subsequent description and analysis are the series of peaks and troughs that characterize participation and production in the ika-shibi fishery in particular (see Figures 3 and 4). As discussed previously in this report, the ika-shibi fishery underwent a downturn just prior to the mid-1980s. Analysts of the day explained this situation primarily in terms of diminished abundance of tuna and secondarily in terms of financial burdens associated with declining catch rates (HDAR 1986). It can be argued that these principal factors have continued to condition participation in the fishery to the present day.

That the abundance of tuna would have a bearing on level of participation and success is quite obvious. But given the many demands of daily life apart from fishing, and the various costs associated with commercial fishing, it is not necessarily axiomatic that fishermen can and will pursue tuna or other pelagic species even when the resources are known to be abundant. Yet, based on all sources of data analyzed during this study, it is clear that when tuna *are* abundant—that is, "when the bite is on"—fishermen will indeed tend to pursue them, and many on a commercial basis. This appears to be the case even when general economic conditions are such that fishing and its perennially uncertain return on effort may not seem the most prudent way to make a living.

For example, a significant economic downturn first began to affect residents of the Big Island during the mid-1980s. The once-vital sugar industry was then declining in a context of few alternative job opportunities. Given that many Big Island handline fishermen were part-timers who often depended on wage and salaried positions on land to cover vessel loan payments, other fixed costs, and at times even trip costs, it might be expected that fishing activity would diminish as fewer fishermen were able to cover the costs of part-time commercial fishing through land-based sources of employment.

But, in fact, there was a notable *increase* in overall participation through much of that period, and thus it appears that many part-timers actually turned to fishing as a source of income and/or food when the unemployment rate on the island was on the rise. Clearly, turning a profit required the presence of tuna, reasonable market prices, and affordable fuel. A network of persons communicating with each other about the presence of fish in the water, and strategies for cost-effective fishing were (and are) also important. It appears that as long as the fish were available and these other conditions could be met, fishermen on Hawai'i Island were at the ready with vessels and gear and sufficient funds and social capital to engage in commercial fishing.

This trend of expansion in the ika-shibi fishery began around 1986. But, notably, it ultimately faltered, and a period of rapid decline in participation and production began after 2000. Significantly, the beginning of the current decade was a time of economic growth in the islands, and a period during which tuna were reportedly less abundant than in years past. Moreover, market conditions on the Big Island were not as stable as in years past. Fuel prices were increasing and many fishermen were aging out of the handline fisheries—with few youth replacing them.

Hence, although complicated by a range of biophysical, economic, and social factors, there appears to be a direct and somewhat obvious relationship between abundance of tuna and participation and production in Hawaii's small-boat handline fisheries, and an inverse relationship between the status of the region's job economy and participation and production in those fisheries. The following pages provide further descriptive context for a more thorough understanding and explanation of these apparent relationships and the variables that likely condition them.

3.2 Ika-Shibi and Palu 'Ahi Operations and Trends: 1986-2004

Hamilton and Huffman's (1997) survey work stands as the most exhaustive and representative examination of cost and revenue dimensions of Hawaii's small-boat fisheries.[12] The study generated a useful template for economic assessment of the small-boat palu 'ahi, ika-shibi, and troll fisheries. Table 4 provides relevant descriptive findings from that research. The figures are based on the responses of research participants who were involved in ika-shibi or palu 'ahi operations for more than 50 percent of their trips. While the data address a single year of operations (1995-1996), they are presented here as reasonable indicators of full-time commercial activity for the fisheries, the time period, and the place of interest.

Table 4. Select characteristics of small-boat commercial operations on Hawai'i Island: 1995-1996

Factor (all figures expressed as means)	**Gear Category** (total n =13)	
	Ika-shibi	Palu 'ahi
Number commercial trips last 12 months	119	205
Number commercial troll trips undertaken	12	24
Usual operating distance offshore	6	2
Maximum operating distance offshore	14	6
Vessel length overall	27	20
Purchase price	$42,556 (std. 33,409)	$11,667 (std. 8,607)
Major gear costs per annum	$5,510 (std. 6,223)	$3,075 (std. 1,520)
Total fixed costs per annum	$11,223	$5,104
Total trip costs	207	180
Days per trip	1	1.25
Crew size	1.7	1.6
Total sales revenue per annum	$70,813 (std. 57,226)	$46,667 (std. 30,139)
Percent income from fishing per annum	93	87
Total household income per annum	46,111 (42,040)	28,333 (15,275)
Age	42	43

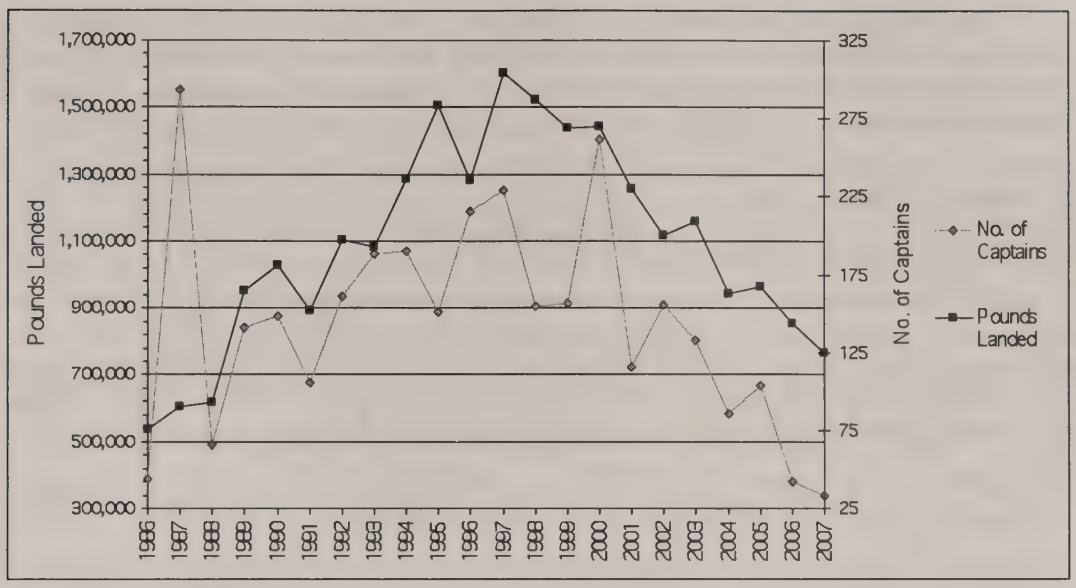
Source: Hamilton and Huffman (1997)

3.2.1 Participation, Catch, and Effort per HDAR Data

As depicted in Figure 3, the period 1986 through 2007 can be characterized by considerable year-to-year variation and by multi-year peaks and troughs in participation and reported landings. A particularly high volume of landings occurred in 1987 when the number of reporting fishermen was quite low, and again in 2000, during a period of extensive participation. Regarding the latter peak, fishermen interviewed during the course of this study recalled a particularly good bite that year.

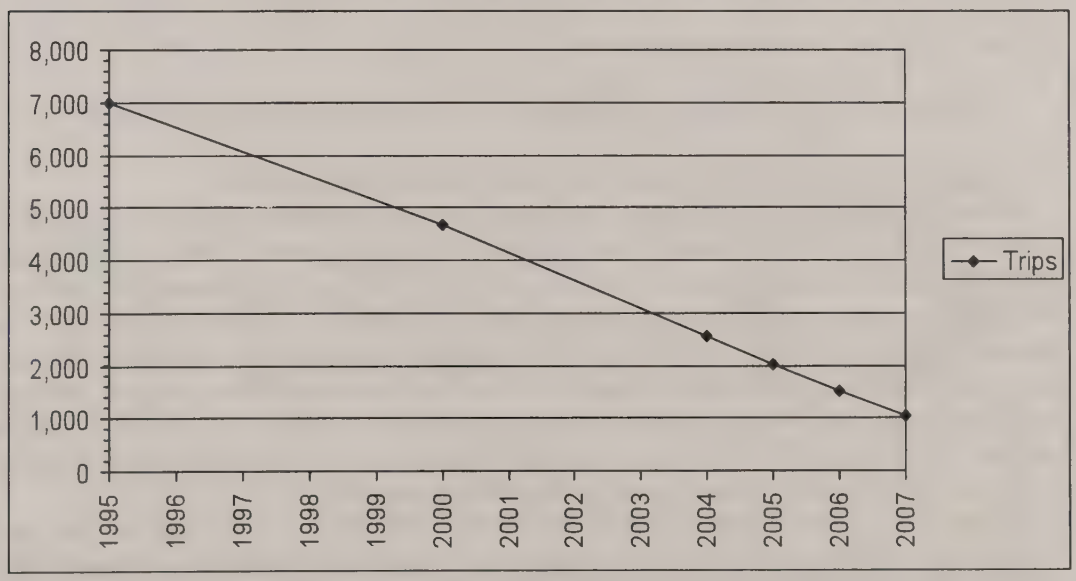
Overall participation in the ika-shibi fishery peaked in the mid-1990s and declined precipitously after 2000. Reported landings (expressed here for all species) have declined in similar fashion since 2000. Effort, indicated by number of reported trips, has steadily declined since 1995 (Figure 4).

[12] An update to the original cost-earnings survey (which was conducted in 1996) is in progress at the time of this writing.



Source: Hawai'i Division of Aquatic Resources

Figure 3. Ika-shibi landings and reporting captains: 1986-2007

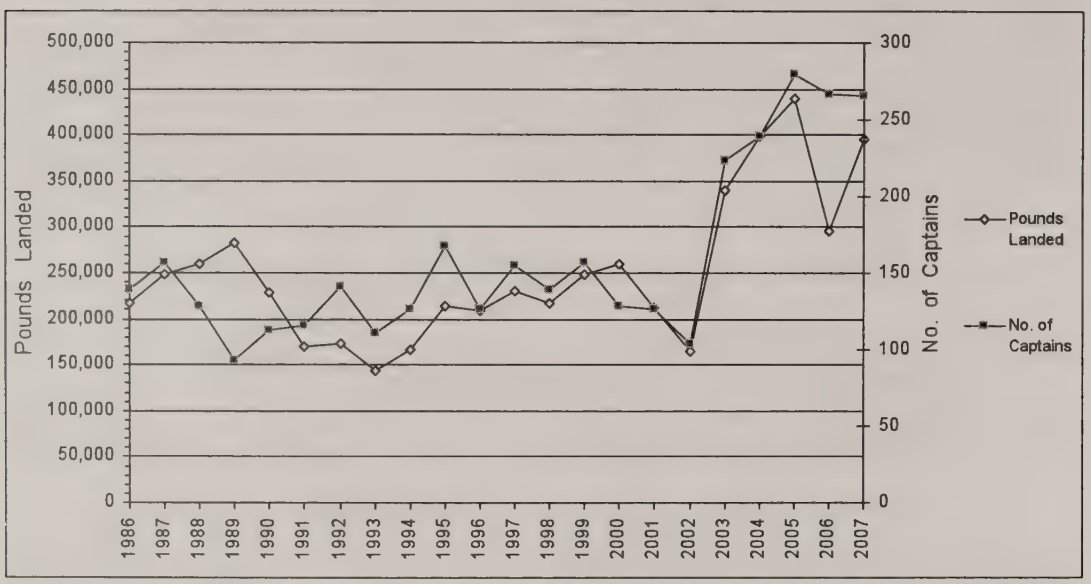


Source: Hawai'i Division of Aquatic Resources

Figure 4. Recent trend of diminishing effort: Reported ika-shibi trips: 1995-2007

A different pattern characterizes the palu 'ahi fishery (Figure 5). There is much less inter-annual variation, and multi-year peaks and troughs in catch and effort are not as noteworthy as during the same time period for the ika-shibi fishery. There is also a relatively close association between participation and production in this fishery.

Note that precise understanding of gear use during the period is confounded by changes in the HDAR reporting forms in 2002, as discussed previously. Thus, the significant upturn in the fishery after 2002 is very likely in large part an effect of the agency's addition of a more distinct handline gear category to the trip reporting form.



Source: Hawai'i Division of Aquatic Resources

Figure 5. Landings and participation in the palu 'ahi fishery: 1986-2007

3.2.2 Spatial Patterns of Reported Landings, Effort, and Residence

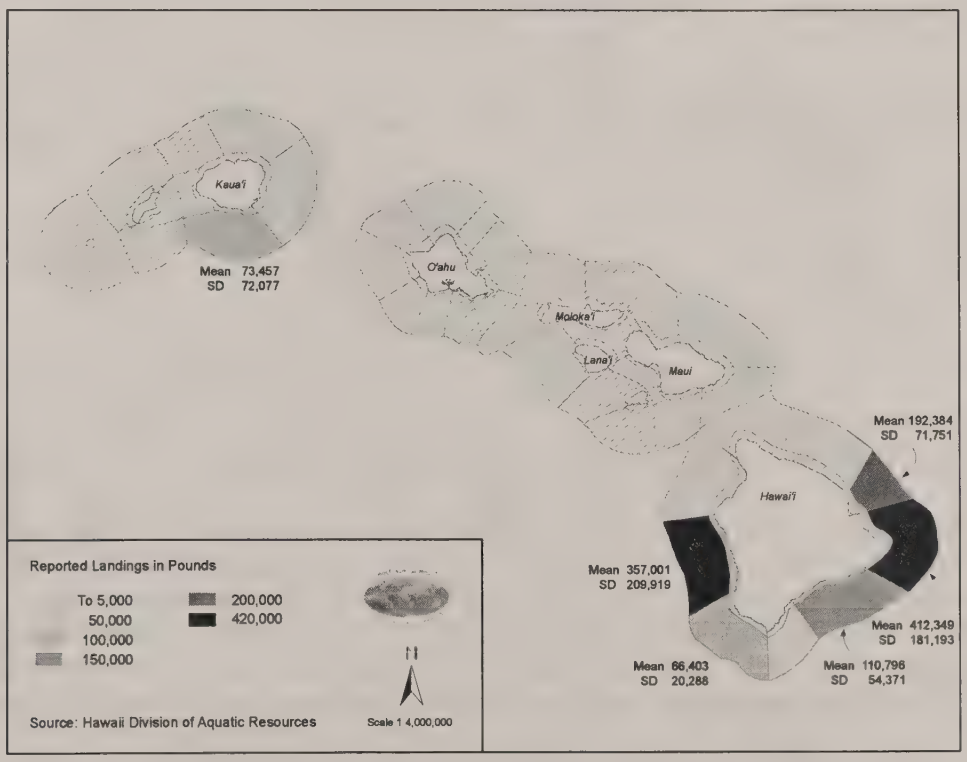
Fishing and seafood are of great importance in local societies around the Big Island and elsewhere in Hawai'i. Observation suggests that some degree of fishing effort occurs during any given year and time of year along even the more remote stretches of coastline. Although not every captain reveals the presence of tuna in a given location, many do discuss their successes and word of a "bite" can be communicated rapidly within and across networks of fishermen and buyers. Even when a captain finds fish but does not reveal information to others, he will typically expend much effort to land fish from that location. Sometimes this involves sustained fishing activity in a specific location, which is visible to other captains who then enter the area uninvited.

In any case, active captains tend to function as monitors of migrating, moving, and feeding tuna. When large schools are present, and especially when they are consistently present within reasonable proximity to land, these rarely go unnoticed by at least some part of Hawaii's commercial and/or recreation-oriented fishing fleets. It is therefore posited here that landings data tend to provide a reasonably consistent indication of the presence of tuna and other pelagic species in a given location or locations over time.

Noteworthy in this examination of archival data is the extent of small-boat commercial harvest that has occurred along the Hilo and Kona sides of the Big Island over the last 20 years. While small-boat captains have long been fishing on a commercial basis throughout the Main Hawaiian Islands, the greatest percentage of reported effort and landings has been registered along the Big Island.

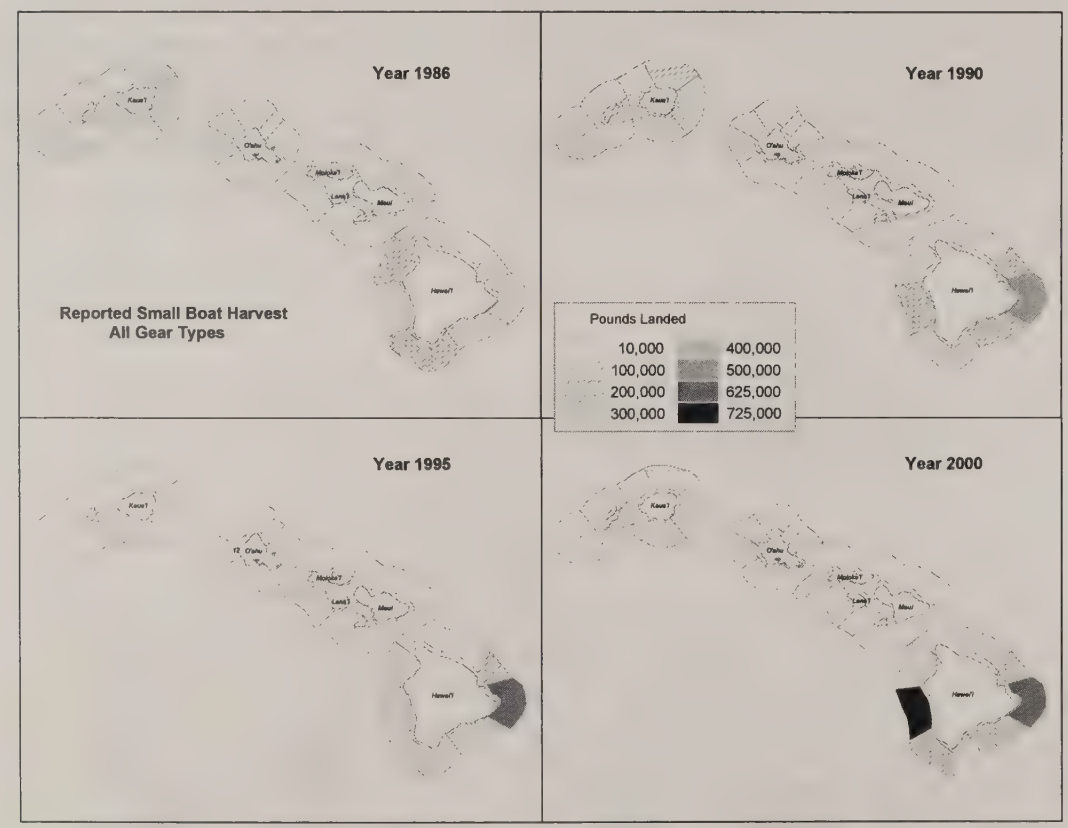
This is clearly indicated in Map 2, which depicts small-boat commercial landings for all gear types and species averaged over the period 1985-2007. Small-boat commercial fishing activity occurring in more distant waters is depicted further along in this section.

The fishing grounds along the Hilo and Kona sides of the Big Island are well suited for pelagic fishing. The ocean is very deep just offshore and suitable bottom features, extensive upwelling and mixing, and other biophysical factors make for favorable conditions. But concentrated effort and productivity in these areas also relates to various human factors. These include: (a) localized historical development of specialized handline methods; (b) the presence of handline fishermen who developed extensive knowledge of tuna ecology; (c) the presence of a public seafood auction (until 2002, when Suisan became an active private wholesaler); and (d) more generally, what Itano (2005) refers to as "critical mass," or sufficient infrastructure and social and fiscal capital needed to consistently maintain productive commercial fishing operations over time.

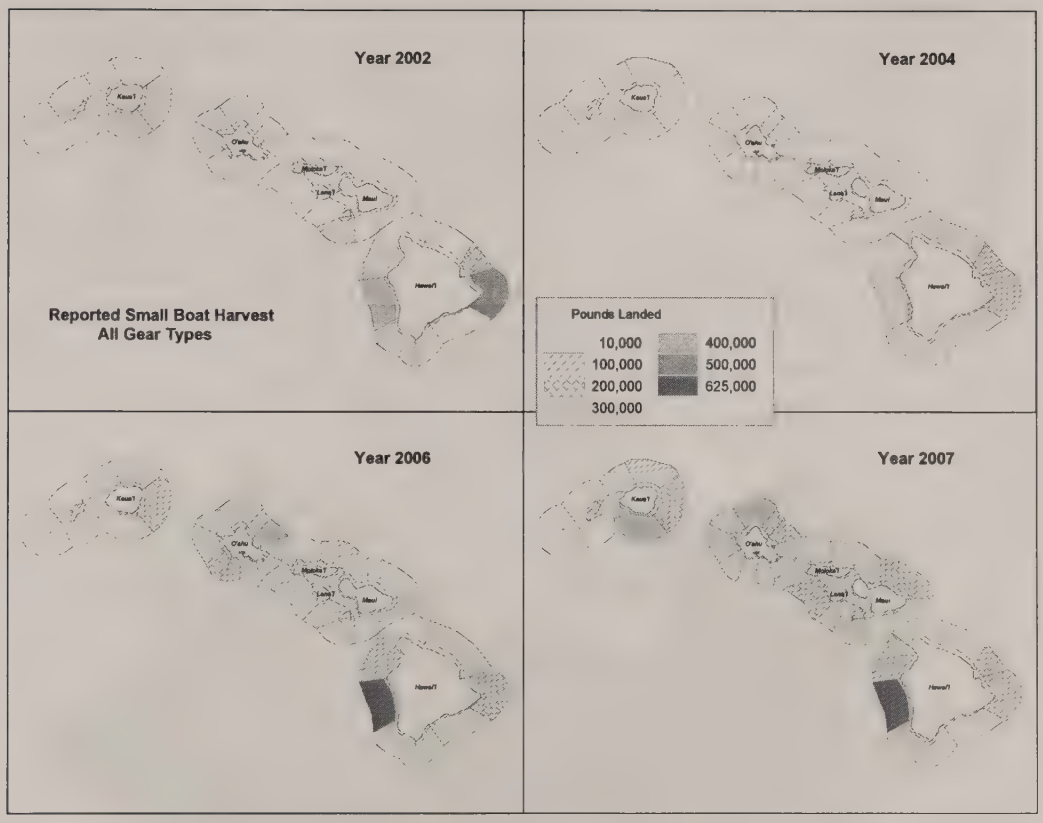


Map 2. Distribution of small-boat commercial landings averaged for the period 1985-2007

This is not to say that commercial handline operations have not been successful elsewhere in Hawai'i. Rather, a combination of human and biophysical factors has led to development of relatively more active and productive fleets around Hawai'i Island. Consistently higher levels of catch and effort along the Big Island notwithstanding, the volume of landings tends to vary extensively between years throughout the Hawaiian Islands. This is illustrated in Maps 3 and 4.



Map 3. Reported place of origin of small-boat landings: Select years 1986-2000

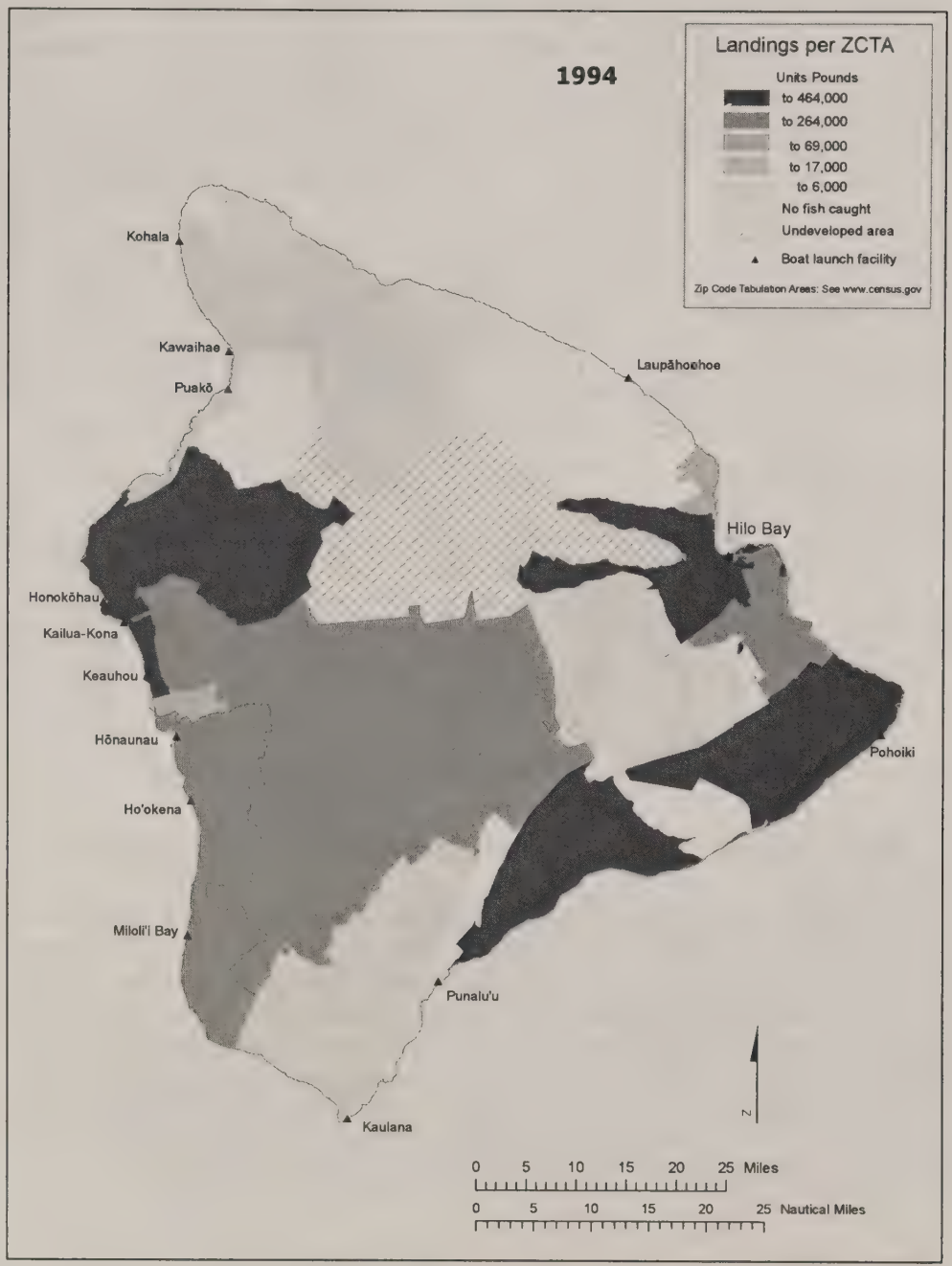


Map 4. Reported place of origin of small-boat landings: Select years 2002-2007

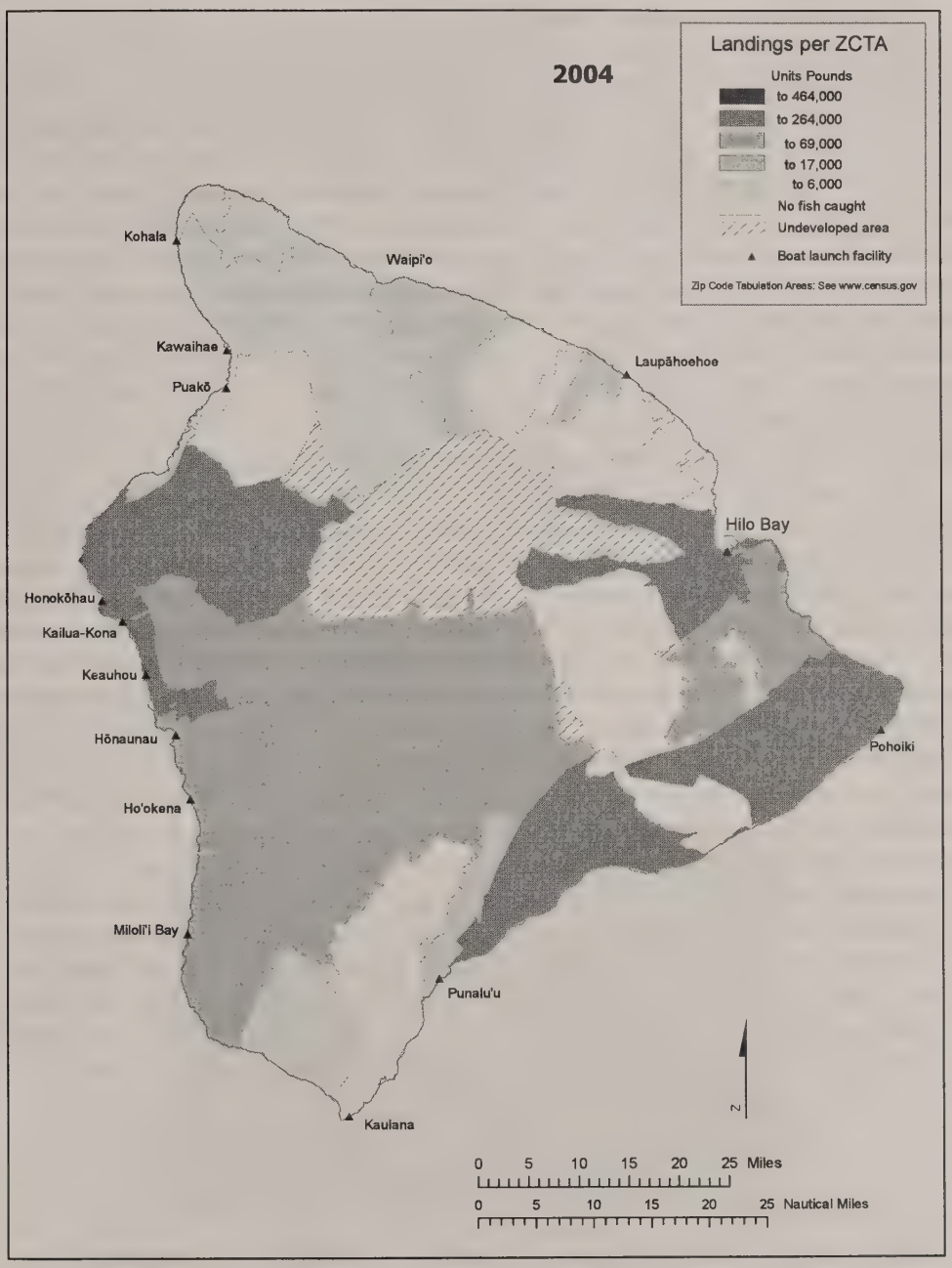
With regard to the development of fisheries infrastructure and small-boat fishing capacity on Hawai'i Island itself, there has been a notable spatial shift in recent years from the Hilo-area beginnings of ika-shibi handline fishing, to both the Hilo and Kona sides of the island. An indication of this change is provided in Maps 5 and 6. The maps, which are based on both HDAR and U.S. Census data, depict small-boat commercial landings for the Big Island by general place of residence of reporting fishermen.[13]

Notable throughout the ten-year period of interest is the concentration of ika-shibi fishermen living in the Hilo, Puna, and North Kona Districts. The overall trend of diminishing ika-shibi landings during this period is also clearly indicated.

[13] Place of residence is represented in general terms. That is, zip codes are used to determine the general area (the Zip Code Tabulation Area) within which each participating fisherman resides. In this case, any given ZCTA typically includes both residential zones and zones that are not habitable due to steep terrain, lava flows, designation as park land, and other limiting factors.



Map 5. Ika-shibi landings by place of residence of fishermen: 1994



Map 6. Ika-shibi landings by place of residence of fisherman: 2004

3.3 Establishment of the PFAD Fishery

3.3.1 Overview and Sampling Strategy

Examination of the ika-shibi fishery and its most recent trend of decline is in part a test of the hypothesis that numerous ika-shibi fishermen had moved to a fishery with a more recent history in Hawai'i— that associated with Private Fish Aggregating Devices (PFADs). Understanding of this fishery is particularly important because recent stock assessments indicate that bigeye tuna is being overfished in the Pacific Basin and because some observers believe that juvenile bigeye are often caught around PFADs (primarily by seine vessels operating in other parts of the Pacific). Given the focus of the overall study on human dimensions of commercial handline fisheries in the islands, and the need to address the research hypothesis, we set out to better understand from sociological and economic perspectives the decline of the ika-shibi fishery and the nature of the local PFAD fishery. This was accomplished in part by consulting with long-time handline operators who were highly familiar with and/or involved in both fisheries, and in part through examination of landings data attributable to persons involved in the fishery.

A social network sampling method (Hanneman and Riddle 2005) was used to identify knowledgeable and experienced fishermen with whom to interact. This involved initial contact with persons widely known to possess expertise in and/or knowledge of the fisheries of interest. Such persons were interviewed and asked to provide the names of similarly knowledgeable persons. This process enabled determination of a preliminary sample of seasoned ika-shibi and PFAD fishermen, which was subsequently validated by long-time observers of the fisheries. Rapport was established with the fishermen and they were asked to identify yet other seasoned participants. Figure 6 depicts the resulting network at an early phase in its development. The most seasoned and knowledgeable captains are depicted at the center of multiple incoming arrows—these are the most consistently active and productive participants who have achieved high social status among commercial handline fishermen in Hawai'i. Such persons are often termed "highliners."

Interviews with such persons and consultation with outside observers between 2006 and 2007 ultimately led to the identification of ~25 captains who were known to regularly fish at PFADs around the Big Island. Interviews also indicated that a lack of tuna, rising fuel costs, and other challenges that were then affecting all small-boat fisheries around the islands were also affecting PFAD operations; only 12 to 15 captains were known to be consistently maintaining PFADs in 2005. This number diminished in 2006 and again in 2007.

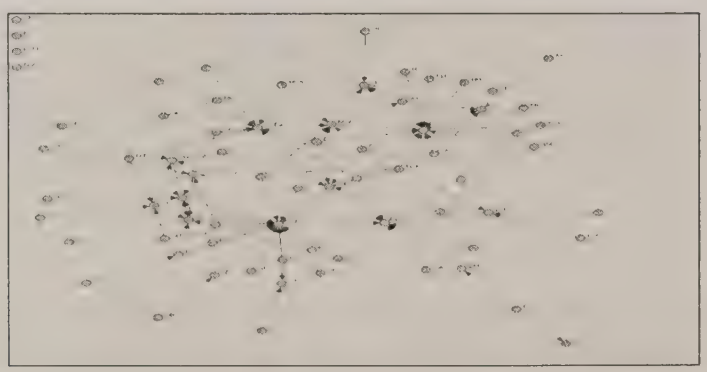


Figure 6. Network diagram of known ika-shibi and PFAD fishermen

Inset C **PFADs and Associated Methods**

Privately established Fish Aggregating Devices (PFADs) include any privately owned device that functions to attract biomass and hence pelagic predators in the upper levels of the water column. Anchor and chain of sufficient capacity are used to retain an appropriate length and thickness of mooring line that, in turn, is shackled to a float system. Mooring lines are often as long as 2.5 miles, which creates a broad swing-circle around the pivot point. The surface buoy or other source of flotation, and associated streamers, attract bait and pelagic fish. PFADs are, in effect, a highly efficient form of fishing gear. They tend to be used in secret and therefore represent a difficult problem for assessment and application of potential management measures.

PFAD technology is straightforward, but mooring and float systems can vary extensively and tend to reflect a balance between cost and effectiveness. Although some are constructed more cheaply, well-constructed PFADs used by small-boat operators around the Hawaiian Islands reportedly can range from about $5,000 to $10,000 per device. The lifespan of PFADs can be quite short in the highly dynamic ocean environment. Nelson (2003) reports that the size of floats and streamers, or "the fish house," is correlated with aggregating efficiency. The reader is referred to Chapman et al. (2005) for discussion of effective FAD planning and construction in the Pacific.

Interview data indicate that PFADs were first deployed along the Kona side of the Big Island not long after the establishment of the State of Hawai'i FAD program in 1980. The privately-established devices, however, were not widely used in the region until around the mid 1990s.

Bigeye tuna and 'ahi are most typically targeted at PFADs. While many captains focus on bigeye tuna in winter, the devices effectively aggregate 'ahi and other pelagic fish throughout the year. Many operators use multiple devices in close proximity. The full range of handline methods are used at PFADs. Captains also commonly troll en route to and while in the vicinity of PFADs. Some PFADs are positioned below the surface to avoid detection and potential entanglement with passing vessels. Geographic Positioning System (GPS) technology is used to mark the general position of the devices.

Derelict PFAD found along the south shore of O'ahu (Photo courtesy of David Itano)

3.3.2 Chronology

Interviews with elderly fishermen along the Kona side of the Big Island indicate that a rudimentary PFAD was established about 30 miles west of Kailua-Kona sometime around 1982. This was a small operation; two fishermen set the device using a trailered vessel launched from Keauhou access ramp. Small-scale operators using trailered boats

reportedly deployed a small number of FADs in the mid-1980s on both the Kona and Hilo sides of the island.

The efficiency of the devices is said to have improved significantly during the mid-1990s, when a particularly knowledgeable former ika-shibi and Cross Seamount highliner entered the fishery. During this period, engineering advances and use of GPS became commonplace. As stories about the efficiency of PFADs spread among prospective fishermen, interest increased, starting capital was located, and more devices were constructed and emplaced. By the end of the 1990s, about ten captains reportedly were maintaining roughly 20 PFADs along the Hilo side of the island, and four or five captains were maintaining eight to ten PFADs along the Kona Coast. Use of PFADs is said to have increased after the year 2000 to around 15 captains deploying as many as 30 devices along the Hilo side, and six or more captains deploying 15 or more devices along the Kona Coast. A shift in landings from primarily yellowfin to primarily bigeye is discernible among our sample of known PFAD operators at about this time (Figure 7).

By about 2003, use of PFADs was beginning to be addressed by the U.S. Coast Guard and by the Western Pacific Regional Fishery Management Council. Coast Guard officials envisioned PFADs as potential hazards to navigation and considered regulatory options that would help prevent collisions and/or entanglement by passing vessels. It was ultimately decided that a logical step was to require that the devices be registered. Meanwhile, the Council decided to designate PFADs as a form of fishing gear. It was during this general time period that incidents involving threats and limited violence were reported after certain fishermen used others' PFADs without permission.

Poor fishing and rising fuel costs in 2005 and 2006 reportedly led many to drop out of fishery and a few PFADs were abandoned due to non-productivity. Knowledgeable fishermen report that while as few as five commercial fishermen were maintaining no more than ten PFADs along the Hilo side of the Big Island in 2007, use of PFADs by charter operators and part-time commercial fishermen along the Kona Coast was likely on the increase. This project did not involve extensive interaction with persons known or thought to be maintaining PFADs along the Kona Coast.

3.3.3 Costs and Benefits

FAD technology is straightforward and effective. It is therefore not surprising that enterprising fishermen would begin building their own devices and strategically locating them in favorable areas around the Big Island, such as above areas of sharp bathymetric relief and in other favorable locations. The potential benefits of using PFADs are obvious: by emplacing aggregating devices on a private basis in favorable locations, individuals or huis (small groups of cooperating fishermen) have been able to approximate the effects of the State buoys. Fishermen report that thousands of pounds of bigeye tuna were often caught around PFADs during single trips in the late 1990s.

Nelson (2003) reports that large FADs tend to aggregate tunas more effectively than smaller devices and that multiple FADs are considered particularly effective. These obvious rules of thumb are clear to the fishermen. But there is interplay between incentives, costs, and actual benefits. While some PFAD operators report that PFAD-specific gross incomes of over $200,000 were common during peak years (such as during the year 2000), highly profitable periods were and are by no means guaranteed, because the presence of tuna can vary extensively year-to-year. Moreover, the investment costs

are not insignificant to many fishermen. Although cheaper devices are sometimes used, the PFADs used by many of the highliners contacted during the course of this study typically cost between $5,000 and $10,000 to establish, and depending on weather and sea states, the lifespan of the devices can be quite short—sometimes no longer than three to six months. Using available materials rather than purchasing new components can help reduce expenditures, but this can also reduce the lifespan of a given device. Trial and error, innovative engineering, capital outlay, and occasionally significant payoff have characterized the process.

While the efficiency of aggregating devices is well known to most fishermen, FADs and PFADs are not universally favored among seasoned handliners. Some believe the devices have disrupted normal patterns of tuna movement and aggregation at natural bathymetric features that were part of the traditional ika-shibi and palu ʻahi fishing grounds, such as those located north of Hilo. This finding is similar to that of Kaneko et al. (2006), who also worked with seasoned handliners in years past. Some fishermen also assert that the state's FAD program has increased small-boat fishing traffic and pressure on pelagic fish populations. While these may have been consequences of the program, its intent was rather to enhance fishing opportunities for the general public.

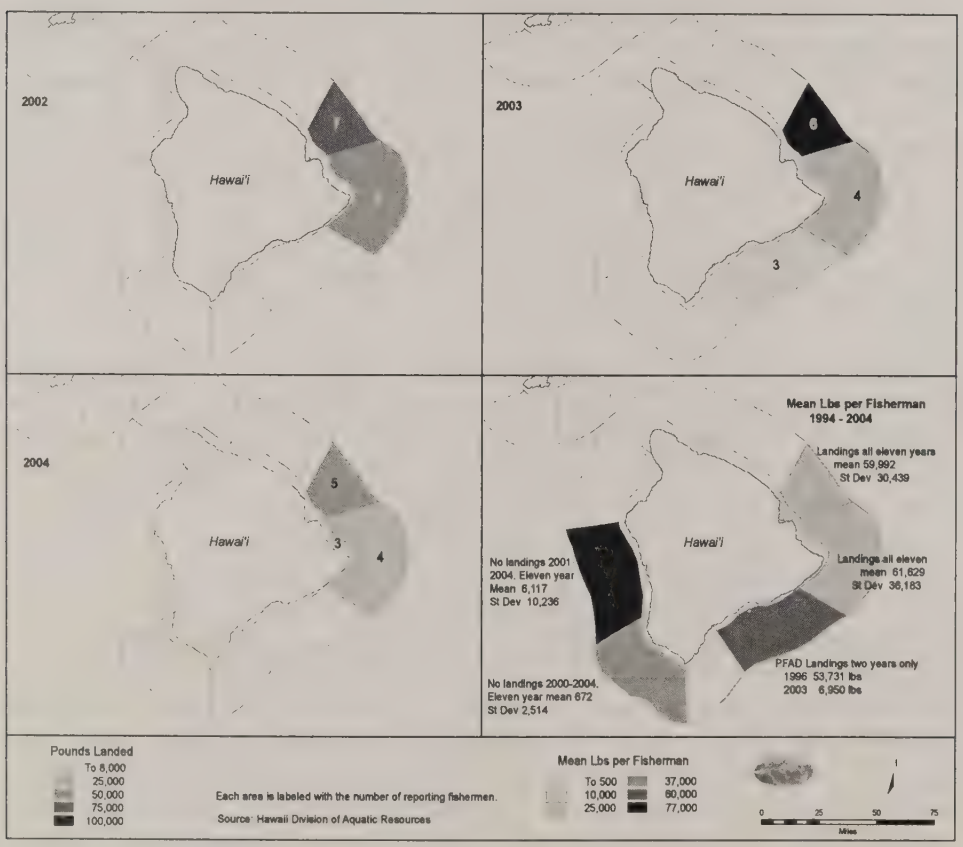
Encouraged by the successful results in Hawaiian waters, the Department of Land and Natural Resources, Division of Aquatic Resources, proposed establishing a system of Fish Aggregating Devices (FADs) in 1979 to revitalize the fishing industry and increase sport-fishing opportunities. The State Legislature appropriated funds for the Department to develop and establish the FAD system. Today, principal funding is derived from the Federal Aid in Sport Fish Restoration Program (FAD Program, State of Hawai'i 2006).

Because PFAD-related profit is perceived or experienced to follow from opportunities to fish around an aggregating device in the absence of other fishermen, secrecy of emplacement and fishing operations has been the norm. Captains typically transport and set their devices under cover of dark, and take accurate GPS readings before returning weeks later to assess the extent of resident biomass. The devices have occasionally been found by accident, and a few captains known to be establishing and fishing FADs have been followed to their devices. In some cases, sole use rights were asserted and defended, as noted previously. One response to this situation and to the problem of potential entanglement by passing vessels has been to keep the aggregating devices at an appropriate depth below the surface. A small number of captains have equipped their devices with satellite beacons, and at least one has installed sonar equipment that can relay images of underwater conditions back to the parent vessel or other remote location.

Some outside observers have stated their concerns about problematic gear interactions between PFAD fishermen and longline fishermen working in distant waters northeast of Cape Kumukahi during the winter months. But in fact, relatively few PFAD fishermen operate vessels of a size that would allow safe and easy travel to such areas on a regular basis in winter, and, moreover, a poor winter run of bigeye rendered this issue largely superfluous in 2006. While inter-fleet interaction issues are periodic in nature and in this case have tended to be resolved over time, historic events, uneasy perceptions, and secrecy have rendered research into these issues quite challenging.

3.3.4 Spatial Patterns of Use

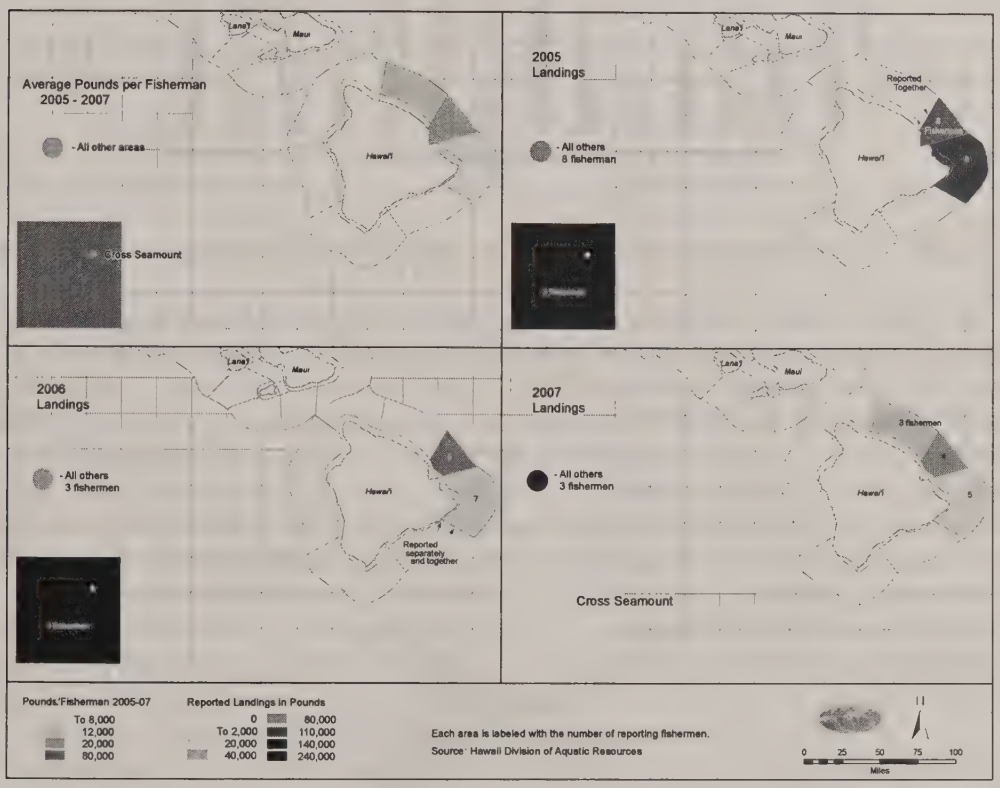
Although information about the specific location of various PFADs has been uncovered during the course of this study, the proprietary nature of those specific data is not compromised here. Because large ocean distances are involved, and the devices are by design often difficult to visually locate, a general indication of spatial patterns of use and reported extent of catch and effort associated with the devices is provided in Maps 7 and 8. The maps derive from HDAR trip data as reported by our sample of known PFAD operators. Interpretation of the data must be conditioned because the summary may not be exhaustive of the full universe of fishermen who have established and/or exploited the devices over the time period of interest. However, it is clear that the sample includes the most consistently active and productive PFAD fishermen, and that the data and analysis provided here address much of the effort and landings associated with the fishery since the mid-1990s.



Map 7. Distribution of landings for known PFAD fishermen: 2002-2004 with 1994-2002 averages

But because the HDAR trip report forms do not include a PFAD gear option (again, the operations are typically secret in nature), the data include landings of tuna caught by the reporting fishermen with all types of handline gear—not only at PFADs, but also at

ko'a, State-maintained FADs, and other features typically frequented by handline fishermen around the Big Island. However, given the level of investment involved in establishing and maintaining PFADs and their aggregating efficiency, it is likely that the data are primarily capturing fishing activity at the devices, at least for certain years in which PFAD fishing was relatively productive. This is supported by interview data, which clearly indicate the ongoing focus of these fishermen on the devices. Note that relatively little PFAD-related fishing activity is known to occur in other parts of the Hawaiian Islands. Bigeye is the primary target, but other pelagic species are also landed at PFADs (Figure 7).



Map 8. Distribution of landings for known PFAD fishermen: 2005-2007

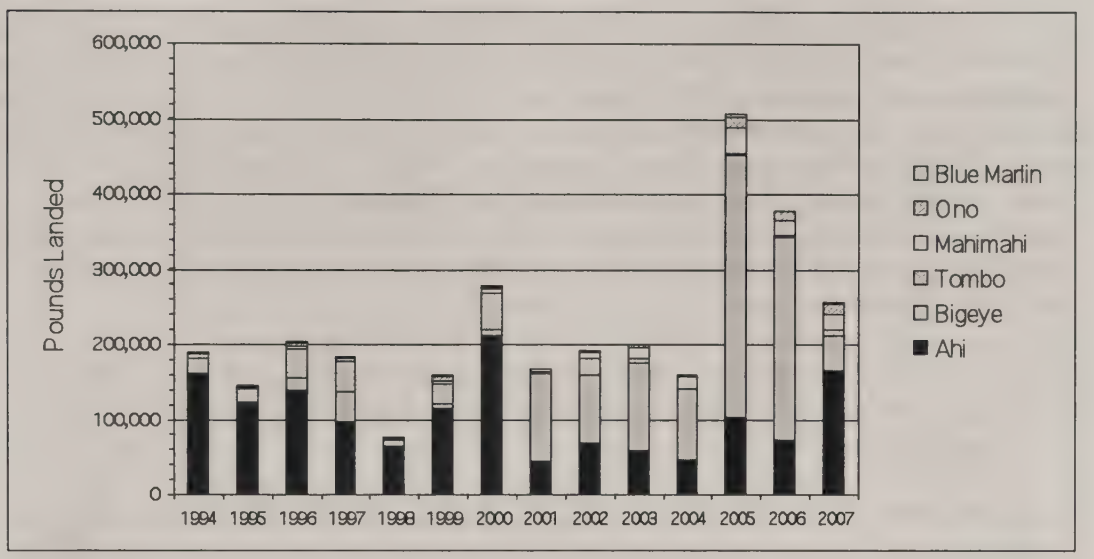
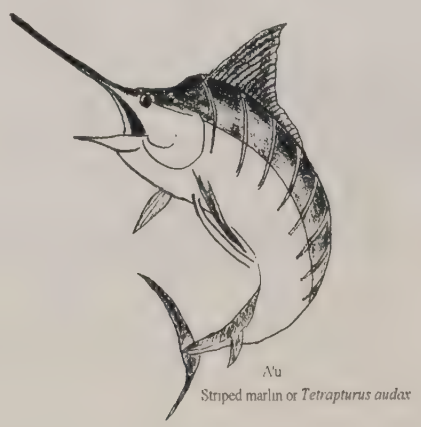


Figure 7. Species composition of landings for known PFAD operators: 1994-2007

As can be noted in Map 8, three of the known PFAD fishermen reported extensive landings from Cross Seamount during 2005 and 2006. This is indicative of the fact that many Big Island small-boat commercial highliners are capable of moving between fisheries, adopting new forms of gear, and generally adapting to new or different situations and opportunities. Some do so to increase the likelihood of increasing personal profit, of course, and/or the profit of their buyers and/or underwriters. Non-monetary benefits are also incentives; for some captains, the possibility of landing large volumes of tuna is an exciting prospect in addition to what can be earned by fishing.



3.3.5 Declining Participation and Production

Engaging in new or different opportunities can also be a response to problems in a given fishery. Despite productive and lucrative trips in past years, data indicate that the PFAD fishery may already be in a state of decline (Figure 8).

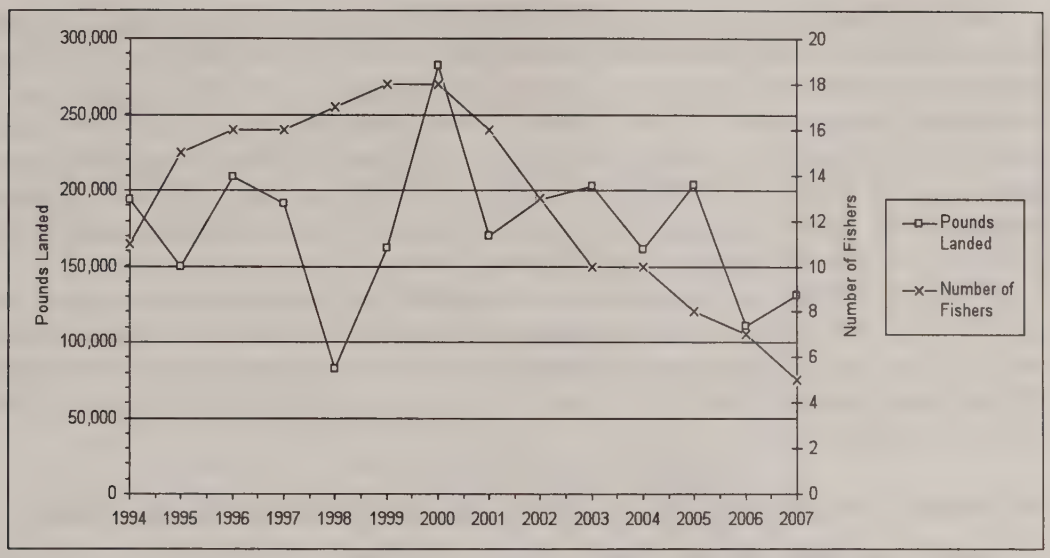


Figure 8. Trends of participation and production among known PFAD operators: 1995-2007

The factors associated with the downward trend are similar to those affecting the ika-shibi fleet and other small-boat fleets across the islands. Rising fuel costs are a particularly significant constraint since some captains emplace PFADs in suitable locations many miles offshore.

3.3.6 Regarding the Ika-Shibi-to-PFAD Hypothesis

Research into the PFAD fishery suggests that while a few highliners did turn to the use of PFADs as an alternative to ika-shibi fishing, a wholesale shift to the new fishery did not occur. Changes in participation and production in the ika-shibi fishery are better explained by the factors reviewed in other sections of this report. In fact, while PFAD fishing has been highly productive and profitable for some, recent challenges make clear that even this highly efficient type of gear is not a pelagic fishing panacea.

It is important to note that successful PFAD operations relate in part to one's ability to maintain good relationships with seafood buyers in the region. This appears to have been the case for relatively few former ika-shibi fishermen. Privatization of the Suisan public auction in 2001 is said to have diminished the opportunity for the average part-time commercial ika-shibi, palu 'ahi, or troll fisherman to readily sell his tuna products. Interview data suggest that the highliners who had developed strong and resilient relationships with buyers were typically better prepared to invest the time and money needed to successfully establish, operate, and maintain PFADs. In some cases, buyers actually co-invested in the operations.

3.3.7 Current Management Framework

Following its proliferation in the mid-1990s, the PFAD quickly became controversial in Hawai'i. In addition to contention associated with secret deployment and use, the devices gained attention from state and federal officials as potential hazards to navigation and as difficult-to-assess components of the region's pelagic fisheries.

The U.S. Coast Guard now requires operators to submit a statement of consistency from the Hawai'i Coastal Zone Management (HCZM) Office, and if emplaced in federal jurisdiction waters, the operator is encouraged to consult with NOAA Fisheries on endangered species issues. If the device is to be emplaced within State jurisdiction waters, permits must be secured from the Army Corps of Engineers, the Hawai'i Department of Land and Natural Resources (DLNR), and the HCZM. As noted previously, the Council determined that PFADs are a form of fishing gear and it continues to assess the fishery in the EEZ around Hawai'i.

At present, PFADs continue to be used under the limiting parameters of operational and market economics, and the fluctuating availability of tuna. Given the secretive nature of the fishery, and because it occurs over such a broad expanse of open-ocean, effective implementation and enforcement of existing or prospective regulations is likely to be challenging.

3.4 Recent Trends in the Cross Seamount and Weather Buoy Fishery

Landings and interview data from reporting participants in the Cross Seamount and weather buoy handline fisheries indicate a peak period of effort in the early 1990s and peaks in landings in the late 1980s and mid-1990s (Figure 9). As noted in Section 2 of this report, participation in the fishery was at its most extensive in the mid-1990s. A clear and steady decline in catch, effort, and participation began to occur after the year 2000.

The recent downward trend and factors contributing to the trend were discussed during the course of numerous interviews with seamount fishermen and seafood distributors on the Big Island. The older fishermen tend to remember days and nights of productive and lucrative fishing at "da mountain." Some associate fishing pressure elsewhere in the Pacific with the recent absence of large tuna at Cross Seamount and around the Big Island. A few describe problems with shifting currents and changing sea surface temperatures. Fewer still relate concerns that their own fishing effort is a significant contributing factor. There is a common belief that abundance is cyclic in nature, and an almost universally stated concern about the increasing costs of pursuing 'ahi and bigeye. These and other factors are reviewed in more detail in the following section of this report.

By the end of the reporting period (2008), only three or four captains were known to be actively and regularly fishing in the far offshore zone. Those still involved report that many former participants dropped out due to increasingly challenging economic factors, especially the rising cost of fuel. Table 5 provides basic information about the nature of a typical commercial handline trip to Cross Seamount. The description was developed from field notes recorded by members of the research team who traveled to the seamount with a long-time captain in the offshore handline fleet.

As can be noted in Maps 9 and 10, and as described in Section 2 of this report, Cross Seamount has long been the primary focus of the far offshore handline fleet. Relatively smaller volumes of tuna have been harvested over time at Buoy Two, with even smaller volumes at Buoys Three and Four, respectively. A relatively small volume of landings is reported to originate in far offshore areas not associated with Cross Seamount or the weather buoys.

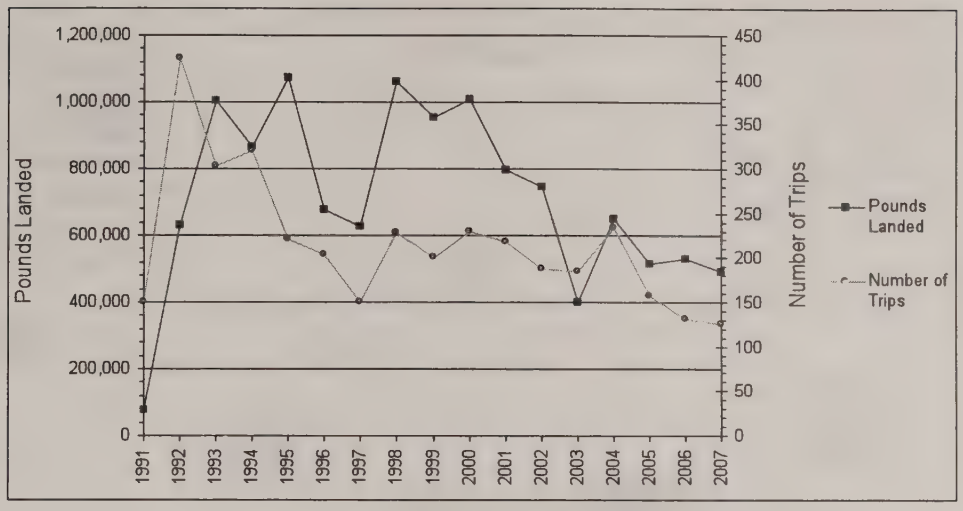
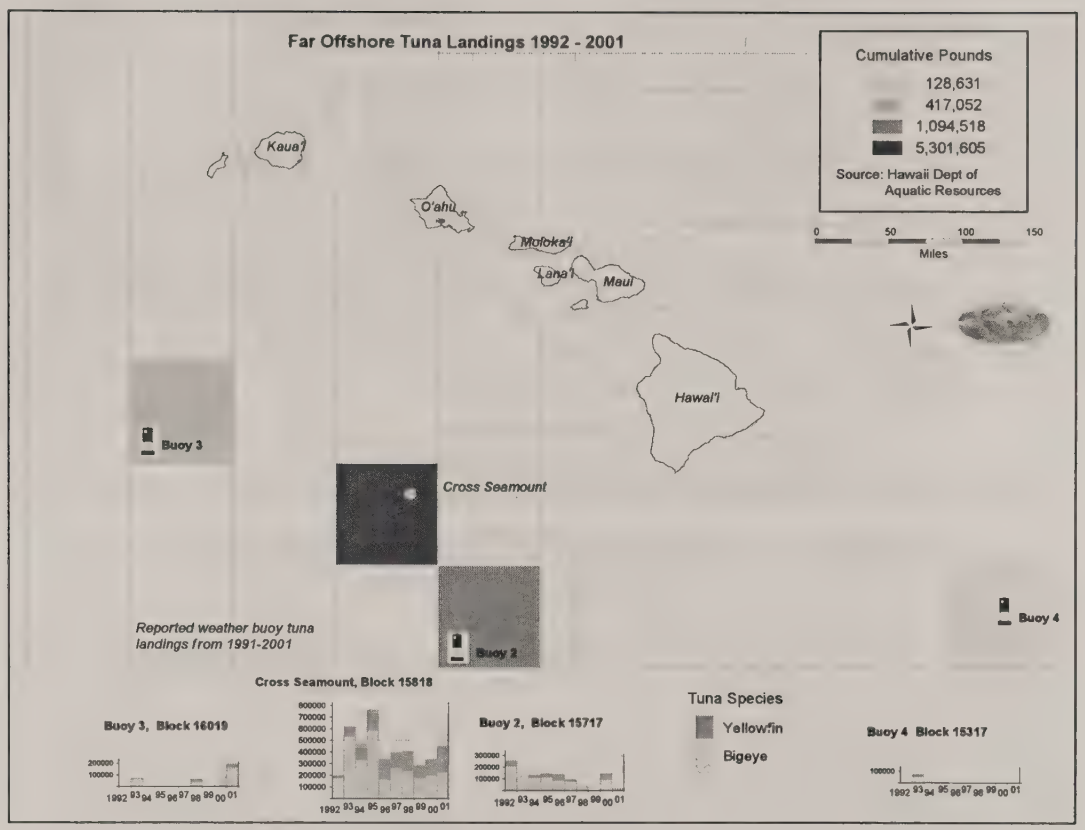


Figure 9. Reported tuna landings from Cross Seamount and the weather buoys: 1992-2001

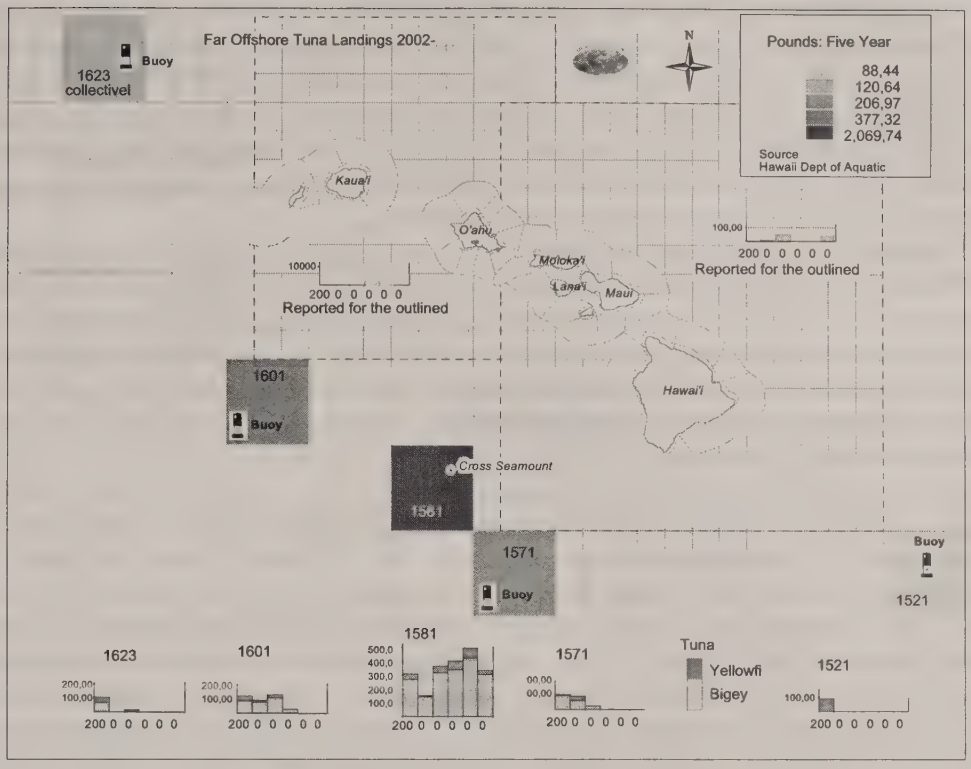
Table 5. Synopsis of a recent handline trip to Cross Seamount

Factor	Description
Date of Trip	September 2006
Origin/Return	Captain and crew regularly move the vessel between Honokōhau Harbor on the Kona side of the Big Island, offshore objectives, and Kewalo Basin on O'ahu. This trip departed from/returned to Honokōhau.
Participants	Seasoned captain, two highly-experienced crew members, and two participant observers.
Objective	Per the needs/ instructions of the buyer with whom the captain has a long professional relationship, the primary objective was harvest of ~10,000 pounds of 'ahi, with the majority of pieces in the 50 pound or greater range. Given the costs have fishing, and the fact that captain and crew had been working hard at sea for many consecutive trips in recent months, rapid achievement of the objective was highly desirable. The crew was given a say in where fishing would occur. Bigger fish reportedly are often caught at the weather buoys, but in this case, the crew opted for what they considered a greater level of certainty of rapidly meeting the 10,000 lb. objective. Trips to Cross Seamount typically last 3- 8 days depending on how soon fish hold is filled. This captain and crew typically make 2-4 trips/month depending on level of success per trip.
Vessel	Approximately 48 feet length overall, ~12.5 feet beam, fiberglass hull, inboard diesel. Full electronics. Small galley. Shower on deck. Vessel recently retrofitted to allow for more working room in the stern.
Method	Troll gear used on the way to the grounds; the fish finder and diving birds indicated the presence of tuna schools. GPS used to locate the seamount and previously productive areas around "the mountain." Once a school was located, anchovy palu was used to bring tuna to the surface. Danglers with colorful squid lures are used almost exclusively on highly/rapidly productive trips, but this trip (and other less rapidly productive trips) involved use of danglers, bamboo poles, handlines, palu 'ahi, and rods and reels. Frozen 'ōpelu and fresh chunks of small bigeye and aku were used for bait on handlines. Short-longlines were used to fish at depth twice daily during the trip; this yielded relatively larger fish, which were marked as longline-caught.
Challenges	The need to return to port with relatively large pieces proved challenging. Captain and crew describe this relatively long trip as atypical; the holds were filled quickly with large fish during trips just prior. Wind and sea conditions are often very rough at the seamount; this proved challenging to the observers.
Outcome	The trip lasted 9 days and fell just short of the objective. Trip-specific gross revenue was estimated to be about $20,000 (9,500 lbs with greatest volume of pieces at 50 pounds or more brought in just under $1.00/lb. plus a lower amount for smaller fish). Trip expenses totaled ~$10,000 plus crew shares (percentages not disclosed). Observation of captain and crew clearly revealed their great knowledge of the resource, fishing, and navigation. Cooperative relationships in challenging conditions impressed the participant observers.



Map 9. Distribution of Cross Seamount and weather buoy landings: 1992-2001

Pole and line action at Cross Seamount, fall 2006



Map 10. Distribution of Cross Seamount and weather buoy landings: 2002-2007

Inset D **Manipulating a Handline at Cross Seamount**

Handlines are particularly useful in that they can be deployed at specific depths in areas known to be favorable for tuna fishing. For instance, if a school is located above a ko'a at 30 fathoms, then the palu and baited hooks can be released at precisely that depth. Once a fish is hooked, its capture is largely a matter of maintaining steady pressure on the line, avoiding any action that might lead it to dive. Care of hands and fingers is critical. The process was repeatedly observed during the study, and is described here based on notes taken during a 2006 trip to Cross Seamount.

The handline fisherman often relies on the traction of his boots and good balance. When a fish is hooked, he braces his knees against the rail, leans back, and rapidly wraps the line in a clockwise direction around his gloved right hand, three to five times. He then rotates his torso toward the center of the deck as his arms and shoulders serve to pull the line carefully up and in, this time wrapping counterclockwise around his left hand. The pulling of the line and rotation toward center is timed in conjunction with the roll of the vessel; he pulls back as the vessel rocks back and quickly takes up slack as it rolls forward once again. As excess line is quickly released on deck, the left hand again deftly winds the line around the right, torso rotating in. The process is repeated until the fish is visible at the surface. The fisherman keeps the line taut while another crewman leans far over the rail to gaff and haul the fish aboard, releasing it from the circle hook amidst a pile of similarly-fated shibi of between 30 and 50 pounds. – Cross Seamount 2006

3.4.1 Deep-Set Horizontal Gear

An early pioneer of handline fishing at Cross Seamount reports that experimentation with long vertically-set mainlines led to the discovery that relatively large bigeye could be caught at depths greater than those achieved using handlines. But when his hydraulic line pullers were stolen from his boat while moored at Kewalo Basin, the innovative fisherman developed a different method for getting at the large tuna. He rigged a drum on which to let out and reel in a relatively short length of reserve longline gear stored at the dock (he was also a part-time longline fisherman).

Subsequent use and experimentation with the gear is described in Itano (2004). It was found that setting the gear up-current and allowing it to drift over certain locations at the appropriate time of day enhanced fishing. Although the method is said to be highly effective, few captains are thus far known to use it on a regular basis. Because these deep-set horizontal lines do not meet the length criteria for true longline gear (which is greater than one nautical mile in length), the method remains unregulated under existing management plans.

Inset E **Deep-Set Gear**

In keeping with economic demands and their own innovative nature, certain captains in the Hawai'i-based commercial handline fleet have continually developed new strategies for catching large yellowfin and bigeye tuna. While experimenting with new types of gear at Cross Seamount during the 1990s, a small group of handliners discovered that by fishing at depths closer to the summit of the seamount, they could catch bigeye that were larger than those normally captured closer to the surface. At one point, a kind of vertically-set longline was used (cf. Preston et al. 1998). This resembles the normal longline configuration (with many baited hooks clipped to a long mainline), but it is much shorter and set vertically, from a buoy on the surface to a weight on the bottom, in this case, along the slopes of the seamount. This configuration subsequently influenced development of deep-set horizontal gear, also known as shortline gear. As illustrated below and as described in detail by Itano (2004), this configuration allowed fishermen to suspend and drift numerous baited hooks at specific depths around the summit of the seamount. Deep-set horizontal gear is thought to hold promise for reducing the capture of juvenile bigeye, and it has also been used to catch various pomfret species (Bramidae), just above the peak of the seamount.

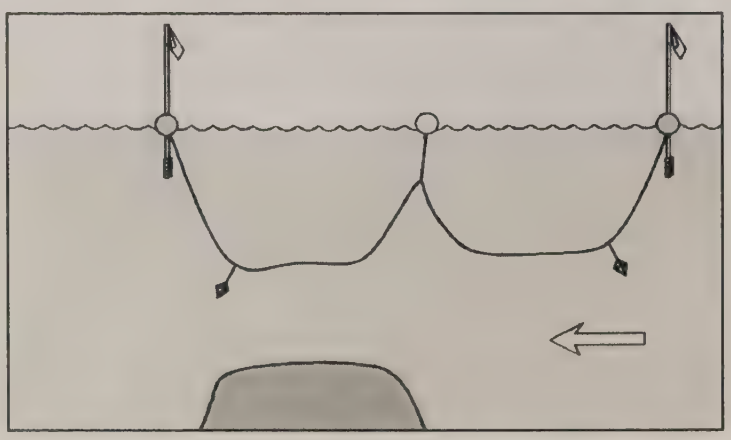


Illustration from Itano (2004)

4. SUMMARY ANALYSIS AND CONCLUSIONS

This section provides summary discussion of patterns of change in Hawaii's handline fisheries. Trends in participation and production are revisited and explained in terms of the various social, economic, and cultural factors that have affected the fisheries both from within and without. The section and report conclude with discussion of the changing nature of the fisheries in the context of prospective management options.

4.1 Dimensions of Change in Hawaii's Handline Fisheries

4.1.1 Fishing and Social Change in Early Hawai'i

The ancient and more recent histories of deep-sea fishing in Hawai'i are directly relevant to the current analysis and to the assertion that all small-scale fisheries are subject to the enabling and constraining effects of large-scale social change. In the case of ancient Hawai'i, social changes both preceded the development of sophisticated and productive fisheries, and led to their ultimate decline. In that instance, declining fisheries were not clearly or demonstrably related to diminishing resources, but rather to macro-social changes which resulted in the diminished collective capacity of Hawaiians to pursue pelagic resources as they had in centuries past.

In his discussion of the initial phase of colonization (~A.D. 300-600), Kirch (1985) postulates linkages between the earliest Hawaiians and settlers of what are now called the Marquesas Islands. This is indicated by similarities between fish hooks recovered at ancient sites in both archipelagos. Adaptive strategies in the Hawaiian Islands included rudimentary horticulture and a variety of fishing and food collection practices; these sustained small nuclear colonies. Societies were not highly stratified and leadership likely assumed a form of hereditary chieftainship that was common across the Pacific Islands at the time.

But as the colonies expanded during a developmental phase (A.D. 600-1100), a distinctly Hawaiian culture and society began to emerge. There were advances in cultivation practices, and Kirch (1985) notes that "the fishing gear, in particular, reflects successful adaptation to local marine environmental conditions and material constraints." This is clearly indicative of the importance of fishing in the transformation of small colonies to established societies. As culture and societal norms developed in response to adaptive needs, the population further increased, with as many as 20,000 persons living in the region at the end of this period. Some degree of sociopolitical complexity is evinced in increasingly elaborate burial practices that involved differential treatment of chiefs and commoners.

Kirch (1985) also describes a period of rapid expansion (A.D. 1100-1650). This involved complex systems of agriculture and irrigation, extensive division of labor, and specialized production of craft items. Specialization in fishing and the crafting of fishing accoutrements was particularly notable. Kirch states that while a distinctive one-piece fishhook design indicates the arrival of immigrants from the Society Islands during this period, this was not highly influential given rapid development of indigenous society and its own capacity to successfully exploit the marine environment. The ahupua'a system was established during this period—in association with increasingly complex and competitive polities. Trade and tributary distribution of seafood were important aspects of social and political life.

Finally, the author describes a proto-historic phase (A.D. 1650-1795) during which economic specialization and production through agriculture, aquaculture, and fishing practices continued "under the auspices of the chiefly class." There was continual political expansion and conquest within and between the islands. At least 200,000 persons inhabited the Islands just prior to contact, though some scholars argue a much higher number (cf. Stannard 1989). Following contact, Hawaiians were affected by foreign viruses and influenced by novel material items and concepts, thereby beginning a period during which a fully established social order and specialized systems of economic production began to change rapidly.

Fishing and seafood were central aspects of the established system of economic production during each phase of development in ancient Hawai'i. As previously described, fishing had evolved to a point at which society was in part organized around the crafting of fishing gear, fishing vessels, and the production and distribution of seafood. In sum, indigenous populations expanded partly because the settlers and subsequent generations of residents developed the knowledge and social capital needed to capture pelagic fish and so provide an important source of nutrition to residents of the various colonies and polities.

It was this critical mass of fishing-related social capital, knowledge, and material culture that was so rapidly affected by the diseases, concepts, and materials that arrived with the Europeans. The social processes that supported the specialized crafting of canoes, fishing line, and hooks, and enabled expertise and cooperation at sea, ultimately failed following the Great Mahele and the dismantling of the ahupua'a. A significantly reduced population, changing modes of governance, and dramatic social change served to constrain individual and collective capacity to pursue pelagic fish on the open ocean.

The subsequent years involved adaptation to new conditions, and blending of long-established culture and knowledge with new ideas and material conditions. A brief period of flourishing commercial fishing activity on the part of Native Hawaiians was quickly superseded by commercial activity undertaken by in-migrating fishermen. A new kind of fishing was established in the 20th century, and indigenous fishing practices and knowledge receded into the background after a period of development that had lasted some 2,000 years.

Inset F **Hawaiian Tribute to the Aku Fisherman**

A no keia lawai'a aku i ku ai ka aolelo keha o ua La'i nei, "Ku'u kane mai na pea huli lua o ku'u aina, he kehau aku ma uka nei a he Ma'a'a mai ma kai, huli ke alo nana ka ihu i ke ka'ao."

It is for this, the aku fishing, that La'i uttered her proud boast, "O my husband, from the dual boundaries of my land, where the dew falls in the upland and the Ma'a'a breeze blows over the low, I turn to gaze at the prows of the canoes in the calm."

-from *Ka 'Oihana Lawai'a, Hawaiian Fishing Traditions* (Kahā'ulelio 2006)

Table 6. Chronology of Hawai'i handline fisheries and relevant events

Time Period	Event or Process
~300 A.D.	Archeological evidence indicates Polynesian voyagers were settling in Hawai'i
300-700	Nucleated settlements; marine resources of great importance
600-800	Increasing social complexity; pelagic fish used as trade item
900-1800	Establishment of complex polities; fishing highly organized
1778	Captain Cook arrives in Hawai'i during exploration of the Pacific; killed at Kealakekua Bay 1779
1820	Arrival of missionaries; disruption of indigenous cosmology
1848	Great Mahele; ahupua'a system disrupted
1893	Illegal overthrow of Hawaiian Kingdom
1899	Nakasuji brings sampan to Hawai'i
1900-	Sugar and pineapple plantations flourishing; many immigrants come to the islands
1903	Native Hawaiians lead commercial fisheries in the islands
1907	Ole Evinrude invents outboard engine
1907	Investors establish Suisan Kabushiki Kaisha, Ltd.
1915	Aku pole and line fishery highly productive; Japanese immigrants dominate fisheries
1917	Macfarlane Tuna Company opens, later becomes Hawaiian Tuna Packers
~1920s	Hilo squid fishermen shift to shibi fishing
1929	Stock market crash; origins of Great Depression
~1930s	Forty captains using ika-shibi methods around Hilo
1941-1945	World War II begins after Japan bombs Pearl Harbor; fishing restricted around islands
~1950s	Three to four captains using ika-shibi methods from Hilo side
1959	Hawai'i becomes the 50th state
1968	Outboard engines, hulls, and electronics much improved
1968-	Post-war economic growth; plantation jobs still plentiful; extensive construction on O'ahu
~1970	Increasing number of ika-shibi captains fishing from Hilo side of Big Island
1973	1970s oil crisis begins
1976	Thirty ika-shibi captains; Cross Seamount being fished by handliners
1979	Palu 'ahi methods increasingly used around Big Island
1979-1980	State FAD system established
~1981	First PFAD reportedly emplaced Kona side of Big Island
1980	Two hundred fifty-three captains using ika-shibi method Hilo side
1984	Hawaiian Tuna Packers defunct
1985	HDAR data collection re-systematized
1987	Peak of ika-shibi production in the 1980s
1992	Council establishes control date for offshore handline fishery
~1995	PFADs becoming more popular
1997	Asian financial crisis begins
1997	Peak reported participation in ika-shibi fishery (304 reporting captains)
1997	Peak participation in offshore handline fishery
2000	High landings year for small-boat commercial fleet
2001	Terrorists attack the World Trade Center, Pentagon, airline targets
2002	Suisan public auction transitions to privatized buyer/wholesaler
2003	Oil and gas prices begin significant increase
2003	Coast Guard and Council begin to address proliferation of PFADs
2004	Hawai'i economy improves after long period of decline
2004	Hawai'i lowest unemployment rate in U.S.
2004	NOAA Fisheries determines that bigeye is subject to overfishing across the Pacific
2005	Control date set for all non-longline commercial pelagic fisheries in Hawai'i EEZ
2006	NOAA Fisheries determines yellowfin is subject to overfishing in Western and Central Pacific
2007-2008	New stock assessments indicate overfishing of bigeye and possible overfishing of yellowfin
2008	Council begins deliberating limitation of entry into far offshore handline fleet
2008	Oil and gas prices increase dramatically
2008	National/international economic crisis begins
Late 2008	Gas/diesel prices ease somewhat

4.1.2 Handline Fishing and Social Change in the First Half of the 20th Century

A few issei brought expertise and, in certain cases, sufficient capital to focus on commercial fishing. Other Japanese immigrants came to the islands to work in the sugar and pineapple industries and turned to fishing when their contracts expired, often using their savings to do so (Kimura 1988). As was the case for Native Hawaiians, Japanese immigrants tended to act on a social norm of cooperation. Indeed, as Schug (2001) asserts, the expansion of commercial fishing in early 20th century Hawai'i was rooted in the cooperative efforts of tightly ordered societies of immigrants, and in the development of close relationships between fishermen and networks of buyers and auctioneers.

Relatively little is known about the original ika-shibi fishermen in Hawai'i. It ***is*** known that they came from prefectures in which the production of seafood and deep-sea fishing skills were highly valued. The innovators of the ika-shibi method undoubtedly drew on old skills and knowledge, and their operations benefited from close cooperation and the support of their families. Moreover, even at this early stage, the harvesters were working closely with other immigrant buyers and marketers at Suisan Kabushiki Kaisha Ltd. Thus, the development of commercial handline fisheries in Hawai'i relates in part to the arrival of social and fiscal capital from a distant land and to continuation of social norms and ethnic ties in a new land. The immigrant fishermen also maintained satisfactory relationships with the indigenous people of Hawai'i and, as indicated by Yuen (1979), they deferred to the knowledge of Native Hawaiian fishermen when developing the new ika-shibi fishery.

During World War II, the Territorial government limited access to the ocean, thereby constraining fishing operations (Allen 1950; Brock 1947). This clearly exemplifies the dampening effect that large scale social change can have on small-scale marine fisheries. In this case, concerns about enemy vessels essentially terminated fisheries being conducted by the issei and nissei, and it severely limited fishing across all the fleets and ethnic groups.

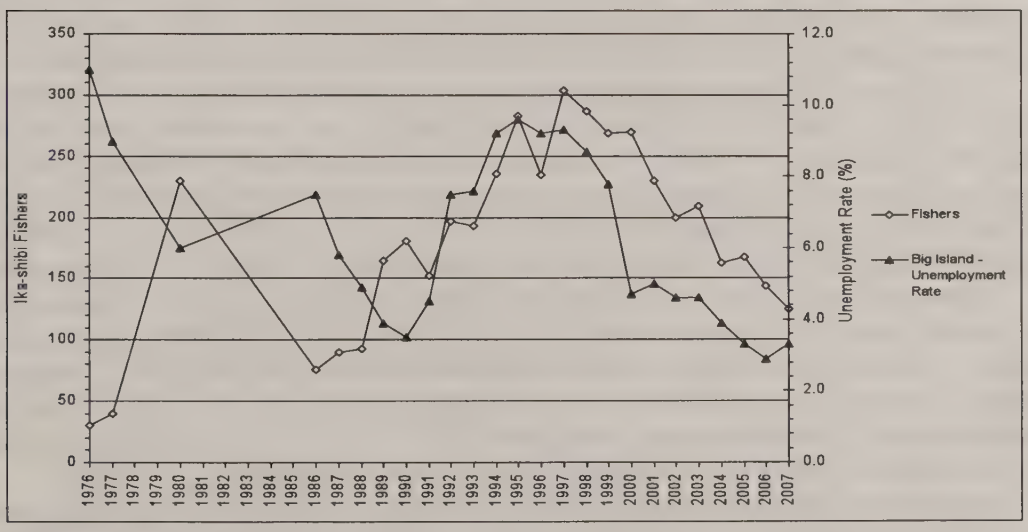
4.1.3 The Land-Based Job-Commercial Fishing Dynamic

Economic conditions and opportunities gradually improved after World War II, as did the materials and technology associated with small-scale fishing. The ika-shibi fleet and other small-boat fleets expanded during the 1960s and 1970s. It was at this point that dynamic interaction between employment and wages, generation of investment capital, and participation in part- and full-time commercial fishing became important analytical considerations in assessing the status of the fleets, as was done by HDAR in the late 1970s and early and mid-1980s. Some prospective local captains of the day were able to draw on inherited and/or earned capital to buy vessels and gear and to begin earning money by fishing. Some were eventually able to earn a living by fishing on a full-time basis. Others fished commercially on a part-time basis, supplementing fishing income with income earned through land-based jobs, and vice-versa.

Post-World War patterns of involvement in the industry relate directly to analysis of contemporary small-boat handline fisheries in Hawai'i. In fact, the male children of numerous fishermen who had managed to purchase vessels and successfully pursue commercial fishing operations during the 1960s and 1970s continue to fish on a commercial basis in the islands, drawing on knowledge and capital generated during years past. Thus, the 'ohana (family and extended family) may be seen as a means for perpetuating the handline fisheries in communities throughout Hawai'i.

In this regard, it should be noted that small-boat fishing operations are unlike those undertaken by captains and crew of relatively larger vessels, such as longline vessels. The latter operations tend to be more heavily capitalized, vertically-integrated, and remotely-owned, and they are often conducted in waters many miles from the islands. Fishing typically continues regardless of sea conditions or other factors that commonly constrain small-boat operations. Although some small-boat captains do consistently fish on a full-time basis, many tend to fish less frequently when pelagic resources are not clearly abundant, when fuel prices and market conditions are not so good, and/or when land-based jobs are readily available. Although boats and gear may lie dormant for periods of time for such captains, the operation can be reinstated when conditions improve and/or when or land-based job opportunities diminish.

Figure 10 is indicative of such patterns. The figure depicts the Big Island unemployment rate plotted against level of participation in the ika-shibi fishery. A particularly high unemployment rate during the initial years of the fishery (when large tuna were abundant and participation was beginning to increase) suggests that commercial fishing was a viable employment opportunity in a rural area with few job opportunities outside the plantations. Numerous captains reportedly came to live on the Big Island during the period and, through various means, were able to invest in vessels and gear. Participation diminished in the mid- and late '80s as captains struggled with a downturn in abundance of large tuna and the economic challenges of fishing itself.



Sources: Department of Labor and Industrial Relations; Hawai'i Division of Aquatic Resources

Figure 10. Big Island unemployment rate vs. participation in ika-shibi fishery: 1976-2007

It is notable that participation in the fishery and the unemployment rate appear to increase and decrease in tandem starting about midway through the time series depicted in Figure 10. Based on these data, it may be posited that when land-based jobs became increasingly scarce during the 1990s, an increasing number of persons become involved in the fishery. During this time, periods of abundant tuna and the fishing lifestyle reportedly attracted new captains and held the enthusiasm of those who had long been involved in the fishery. New construction activity had stalled, the plantation era was pau (finished), and

fishing was one of few employment options for rural Hawai'i Island residents. But as the economy began to improve in the new millennium, and as tuna reportedly became more difficult to locate and catch after a peak landings year in 2000, participation in the fishery began to diminish rapidly, falling in 2007 to its lowest level in nearly 20 years. Rising fuel prices during this period may also help explain the downward trend.

While overall rates of participation in Hawaii's handline fisheries have varied considerably over the years, certain captains have remained dedicated to commercial fishing. Some ventures have periodically been lucrative, and the goal of maintaining (or re-gaining) profitable operations is often highly motivating. The support of seafood distribution firms, and akamai (smart) decision-making and relationship building on the part of fishermen have been important factors in the longevity of certain fishing operations. The non-monetary benefits of the lifestyle can also influence captains and crews to continue fishing, or to focus primarily on fishing despite the challenges. Freedom from the workplace on land, enjoyment of the ocean environment, and satisfaction achieved by enacting strategies for catching tuna and other pelagic species on the open ocean are powerful motivations for many.

4.1.4 Regarding Recent Trends

Based on findings from both primary and secondary source research, it is clear that participation and production in the ika-shibi fishery has fluctuated most obviously in association with the availability of tuna. There have been periods of extensive and profitable activity, but these have been followed by periods of decline that cannot be adequately explained without considering the relative absence of bigeye and yellowfin.

For instance, the initial spike of ika-shibi activity during the mid- to late-1970s was followed by a period of declining participation and production that HDAR representatives explained first in terms of "noticeable decline in availability of large tuna," and secondarily in terms of financial burdens associated with capitalization amidst declining catch rates and marketing problems. The status of the fishery was related to a number of variables but abundance was the principal factor of consideration.

Subsequent improvement of the ika-shibi fishery between the mid-1990s and the turn of the new century has been followed by another period of decline that continues to the present. The downward trend parallels that of small-boat fisheries in the islands as a whole, with greatest consequence on the Big Island where the vast majority of small-boat landings occur. Fishermen today often report many nights of catching only one or two pieces, with more nights of no catch than was typical in years past.[14]

Assuming favorable prices at the point of distribution, and stable trip costs, a steady supply of large pieces would obviously have satisfied fishermen and led to stable or perhaps increasing levels of participation (and levels of production) over the years. But the seasoned fishermen contacted during this study almost universally claim that large bigeye and 'ahi specimens have become increasingly scarce in recent years, and that trip costs have risen steadily.

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[14] This statement is intended to indicate the nature of a general trend. But it must be noted that there can be periods of significant activity within such trends and that these may portend a shifting trend. For instance, numerous trips resulting in three and four shibi per night were being reported from Pohoiki on the Big Island during the spring months of 2009.

4.1.5 Results of Focused Questioning with Highliners

Examination of these issues was reiterated during in-depth discussion with a core group of 21 highline handline fishermen during 2007. The highliners were asked to consider a variety of challenges that had been described by fishermen throughout the study. The highliners reported that a relative lack of abundance of tuna, rising fuel costs, and fluctuating prices for tuna were the most compelling challenges they face today. Some also reported that fishing pressure occurring elsewhere in the Pacific Ocean, and the costs of maintaining vessels and gear are significant challenges (Figure 11).

The highliners did not consider certain issues to be as important as they had been in years past. For instance, concerns about competition with locally-based longline operations were preeminent during PFRP-funded research conducted with small-boat fishermen in the mid- and late 1990s. Today, distant purse seine and other remote fishing operations are commonly thought to be the principal source of pressure on tuna stocks in the Pacific, with negative implications for all Hawai'i-based pelagic fleets. This sample of highliners included numerous fishermen who operate PFADs, and thus few in the sample discussed the potential for FADs in general to disrupt patterns of movement and migration of tuna as asserted by other fishermen during the course of this study. Similarly, because the sub-sample was biased toward full-time commercial operators who generally are not keen on engaging in land-based employment, there was little stated concern about the availability of alternative forms of employment.

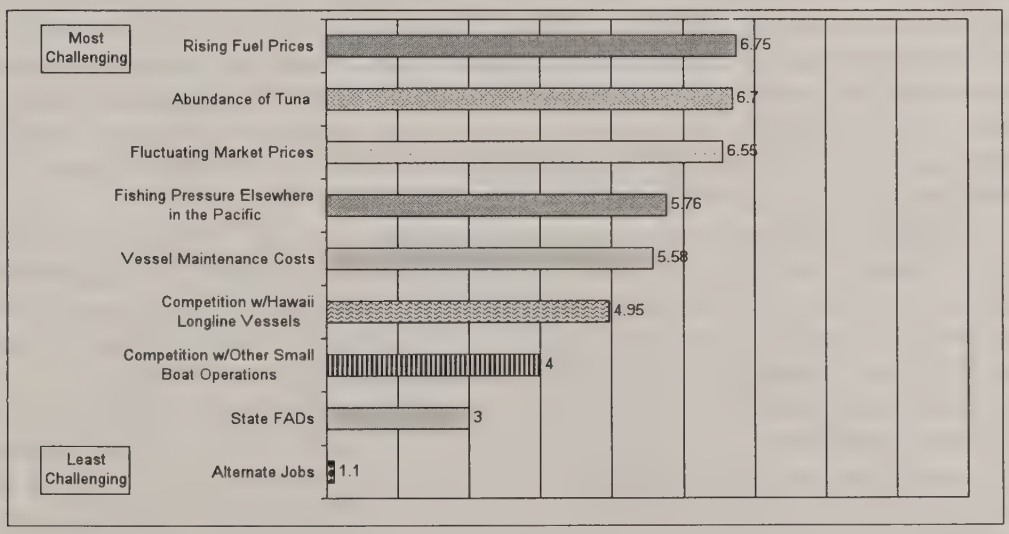
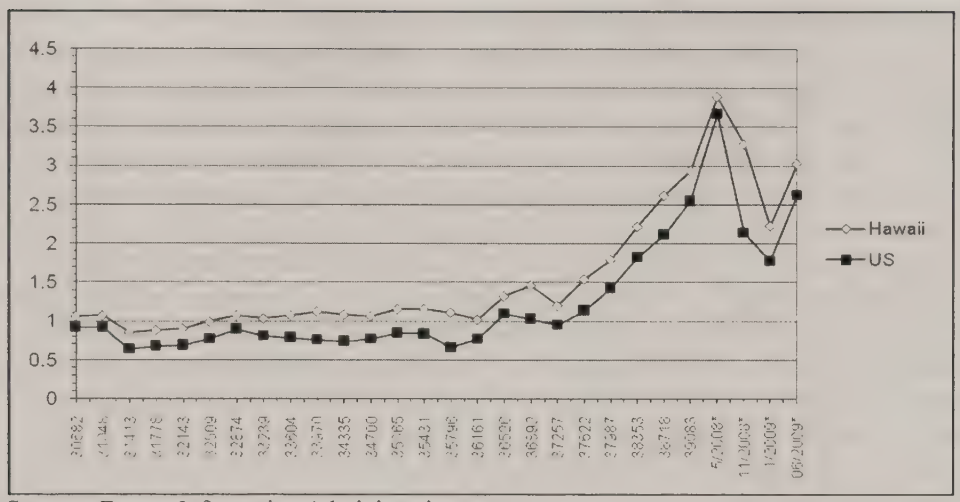


Figure 11. Highliner ranking exercise: Fishing-specific challenges and concerns

Fuel costs were repeatedly discussed by fishermen during the course of this research. The constraining nature of rising fuel prices is obvious and many fishermen report that this factor has increasingly limited how many trips they take and how far they travel at sea. While gas and diesel prices eased somewhat at the start of 2009, and seasoned fishermen said this would enable them to fish more often, farther, and longer, prices had begun to rise once again by early summer.



Sources: Energy Information Administration

Figure 12. Trends in the cost of fuel: U.S. and Hawai'i: 1984-2009

4.1.6 Market Prices

Small-boat commercial fishermen, including handline fishermen, often discuss pricing challenges. A common assertion is that that buyers tend to pay less for small-boat products than for tuna caught from longline vessels. Some observers assert that this relates to a quality differential associated with the metabolic effects of rapid and excited expiration of tuna on handlines versus less rapid and less excited expiration on longlines (or troll gear). While a full accounting of the many factors that condition fluctuating prices and differential pricing[15] at the auction house and other venues is beyond the scope of the current analysis, some notable social factors bear mentioning here.

First, small-boat commercial operators have had to rectify the historic tuna burn stigma discussed earlier in this report. There is no doubt that small-boat captains now very typically take the necessary steps to prevent oxidation after tuna are landed. Moreover, the auction houses began coring and presenting flesh to the buyers during the late 1980s and conducting temperature probes during the late 1990s. Such steps notwithstanding, historic problems reportedly have affected pricing, even in recent years.

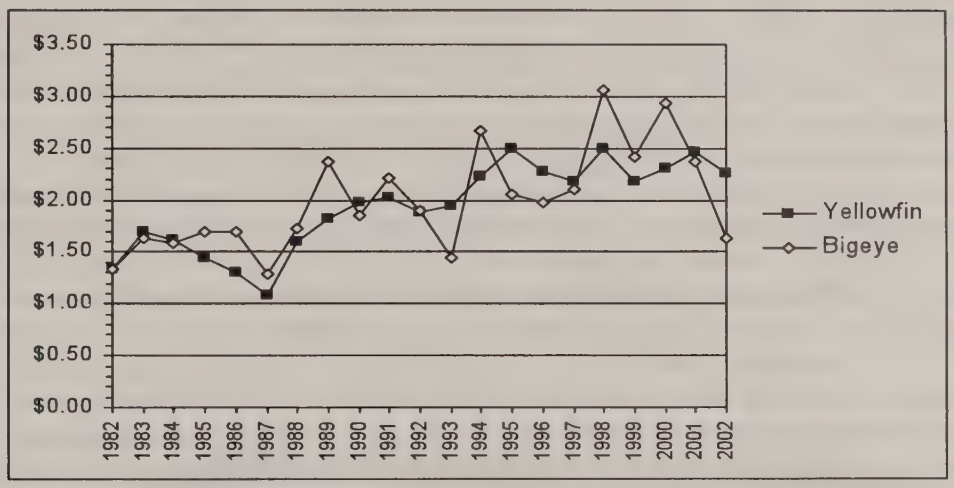
Second, while most part-time commercial small-boat captains have not interacted with specific buyers on a perennially consistent basis (tending rather to sell at open auction), many full-time small-boat operators have developed close professional relationships with specific buyers. This can dampen the effects of uncertain pricing and enhance the likelihood of long-term success.

Finally, it should be noted that pricing is an important consideration in a cumulative sense. That is, not all fishermen are continually prepared for unexpected reductions in return on investment. In fact, at any given time, some commercial fishermen may be considering an exit from the industry, and poor prices coupled with other challenges may nudge him over the threshold of departure. This is said to have been the case for numerous already-struggling ika-shibi operators when the Suisan public auction

[15] Useful examples of projects that have examined tuna pricing and related issues in Hawai'i seafood markets include those conducted by Bartram et al. (1996), McConnell et al. (1998), and Peterson (1973).

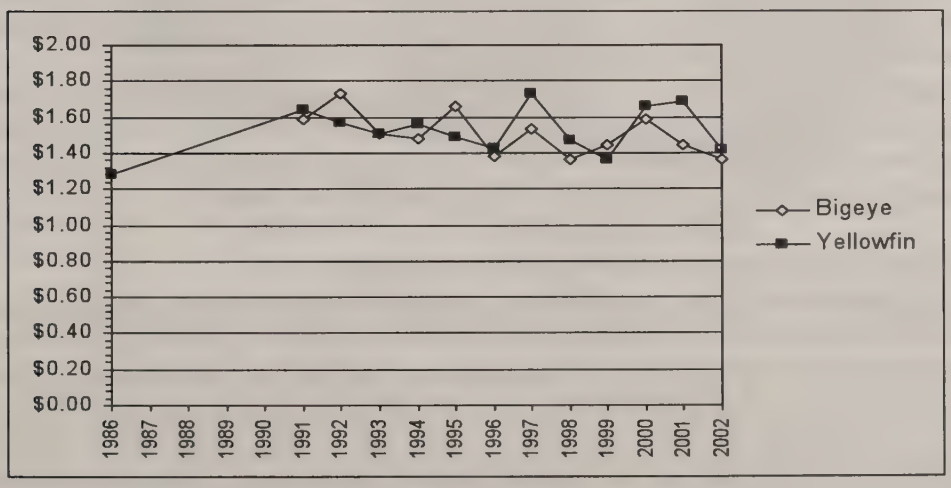
privatized in 2002, ostensibly altering the nature of a marketing venue that many fishermen had grown accustomed to.

Figures 13 and 14 depict available ex-vessel value data for the nearshore and far offshore commercial pelagic handline fleets. The data are based on trip reports submitted by the fishermen to HDAR. The time series ends at 2002, the point at which HDAR and WestPacFIN (the regional data analysis unit of NOAA Fisheries) began the process of integrating trip report data and dealer report data. Figure 15 depicts integrated ex-vessel value data for tuna for the entire commercial handline fleet for the period 2003-2008.



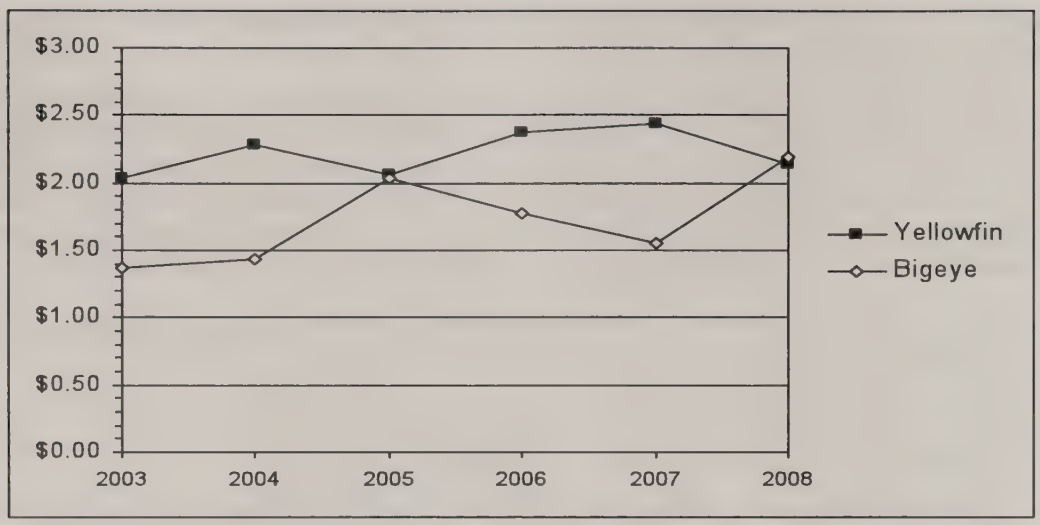
Source: Hawai'i Division of Aquatic Resources

Figure 13. Average market prices for yellowfin and bigeye: Nearshore handline fleet, 1982-2002



Source: Hawai'i Division of Aquatic Resources

Figure 14. Average market prices for yellowfin and bigeye: Far offshore handline fleet, 1996-2002



Source: Hawai'i Division of Aquatic Resources; NOAA Fisheries Pacific Islands Fisheries Science Center

Figure 15. Average market prices for yellowfin and bigeye: All handline fleets, 2003-2008

Of particular note when comparing Figures 13 and 14 is both the apparent inter-annual volatility in pricing for tuna landed by the nearshore handline fleet, especially for bigeye, and the relatively higher average value paid for the products at the marketplace. Volatility relates in large part to fluctuating supply and demand at the auction house and the presence or absence of quality tuna landed by small-boat captains. Pricing for tuna landed by the far offshore fleet is relatively more stable between and across years, indicative of direct and ongoing working relationships between a smaller group of fishermen and their buyers. That the actual prices are relatively lower is indicative of a size/quality differential and the way in which large batches of fish are consistently transacted between the offshore fishermen and specific buyers.

The average value of bigeye tuna landed by the overall small-boat fleet reached its peak in 1999 at $3.00/lb. The average ex-vessel value for longline-caught bigeye was approximately $2.80/lb. that year (per data provided to the Principal Investigator by the National Marine Fisheries Service, Honolulu Laboratory in 2001).

4.1.7 Potentially Important but Out-of-Scope Issues

Some constraints on commercial fishing are difficult to substantiate. While one objective of the current research is to document the varied experiences reported by or observed of fishery participants, verification of certain assertions made by those participants is beyond the scope of the project and rather within the scope of related biological and oceanographic research. One such assertion, albeit limited in frequency, is that there are regional populations of bigeye and 'ahi and that the genetic composition of these populations may have been altered through selective removal of large individuals earlier in the history of the ika-shibi fishery. One long term observer further speculates that targeting of large fish during dark nights in the early years of that fishery may have affected spawning behavior and movement patterns in the long term. Testing of the more commonly stated assertion that the

State-maintained FADs, and more recently PFADs, have altered patterns of movement and migration of tuna is also obviously beyond the scope of this project.

4.1.8 Innovation and Persistence

As noted previously, some commercial fishermen tend to avoid land-based work in favor of fishing. Some are particularly talented at their trade and persist despite the cyclic nature of fishing and associated challenges. Persistence and innovation tend to go hand-in-hand. Our sample of highliners and other seasoned fishermen include those who initiated the PFAD fishery, the Cross Seamount and weather buoy handline fishery, vertical longline gear, the dangler fishery, the new deep-set "short-line" fishery, and use of mixed or hybrid methods in a single trip. These participants tend to be resilient and knowledgeable of: the resources; related oceanic and climatic factors and conditions; the effective and cost-efficient configuration and use of fishing vessels and gear; and market economics.

It is particularly significant in this analysis that the most consistently successful fishermen have managed to develop and maintain good working relations with seafood buyers and distributors on the Big Island and in Honolulu. Yet some among even the most dedicated in this group discuss a need for occupational plurality, particularly given the recent confluence of challenges. This situation is depicted in Figure 16, which indicates the decreasing amount of time that highliners in the commercial handline fleet have recently been applying to labor in their commercial fishing operations.

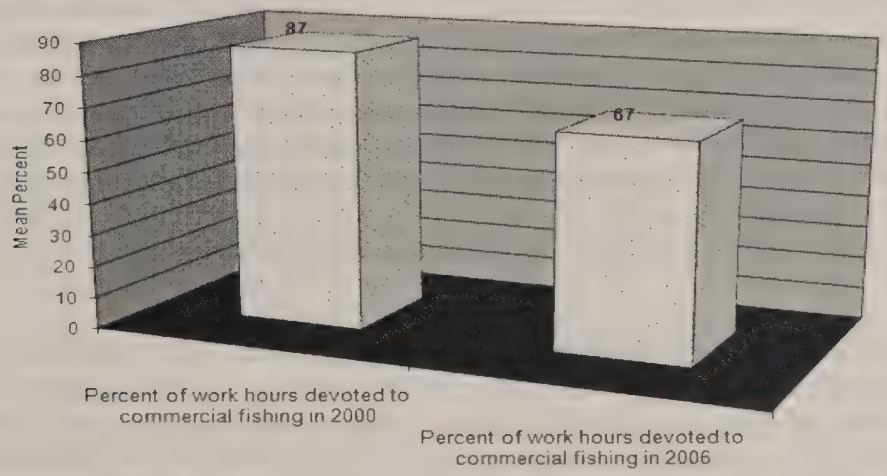


Figure 16. Reduction in time spent commercial fishing (among 21 highliners)

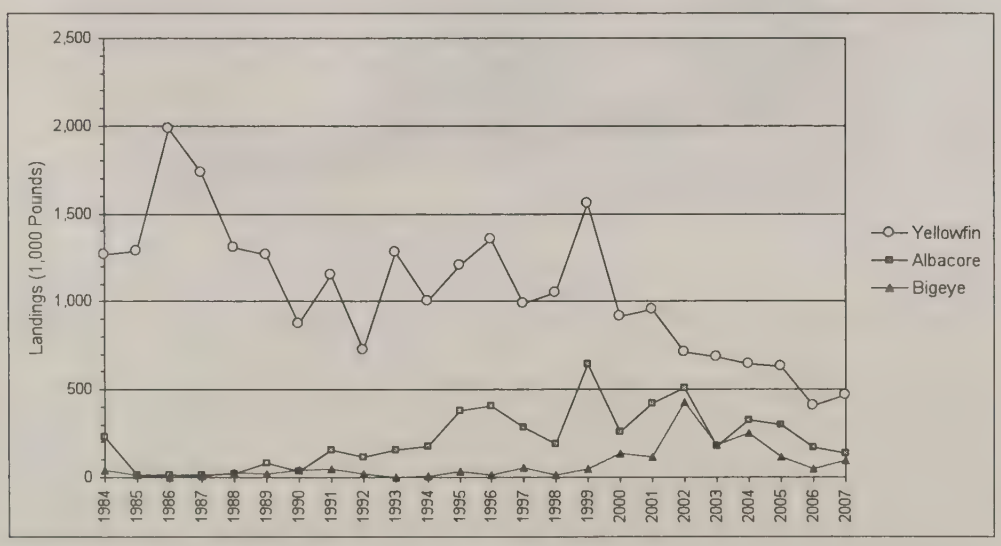
It appears that the many challenges inherent in commercial fishing in Hawai'i (and elsewhere) have tended to limit the number of operators who are able to persist on a full-time or consistently avid basis over the course of time. For instance, the challenges and costs of fishing in the distant waters above and around Cross Seamount and the weather buoys ultimately served to winnow that fleet to its current size of less than five captains. The fleet may eventually expand once again, but this will likely require a change in economic context and a trend of increasing availability of large tuna.

Time itself has also affected the extent of participation in Hawaii's handline fisheries. Some of the most active fishermen in the ika-shibi fleet have passed on, and others have "aged out" due to the physical demands of that challenging night-time method. Still others have shifted to palu 'ahi methods, which involve somewhat less labor. A few fishermen reportedly had problems with drug use in association with periods of extensive profit, and are said to have dropped out as a result of those challenges.

In any event, our initial research hypothesis that an increase in PFAD-related fishing activity was the primary factor underlying the recent trend of decline in the ika-shibi fishery appears at least partly false in social terms, and uncertain and out of the scope of this research in biological terms. That is, explanation that declining participation and production in the ika-shibi fishery relates primarily to a shift of fishing effort to PFADs is verifiably confounded by numerous social and economic factors that have reportedly led many fishermen to leave the industry altogether—at least temporarily. These include: (a) rising trip costs; (b) marketing problems, including those related to fluctuating tuna prices and the shift away from an open auction at Suisan; (c) demographic changes, i.e., many formerly productive fishermen aging out of or leaving the fishery; and (d) a lack of tuna.

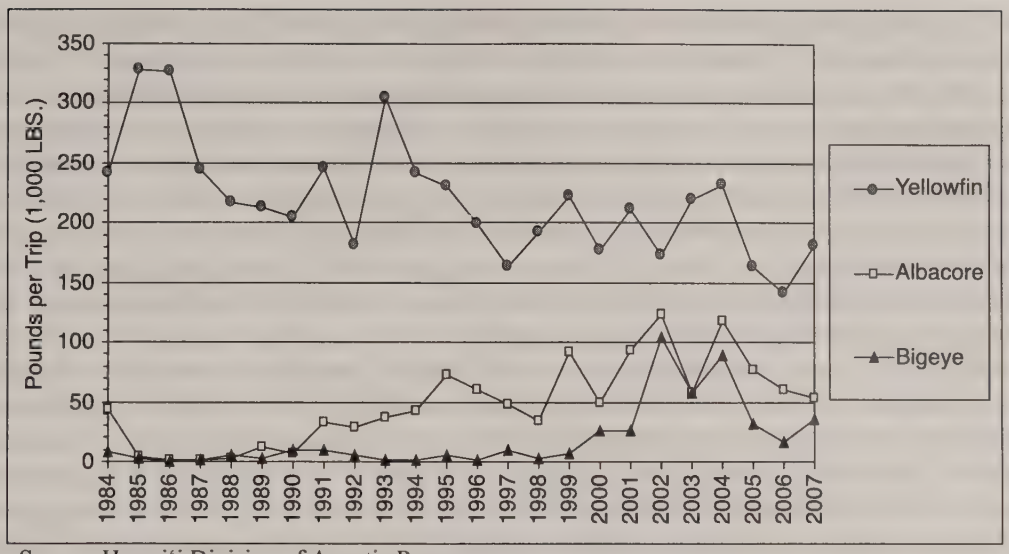
In reiteration, while a group of highly productive fishermen shifted over to the novel PFAD operations, there was not a wholesale shift to use of the devices. In fact, ika-shibi fishing is still common along the Hilo and Kona sides of the Big Island, and it appears that expenses associated with installing, maintaining, and fishing PFADs amidst the periodic absence of tuna can quickly render that fishery as challenging as any other.

Nevertheless, as indicated in Figures 17 and 18, small-boat commercial operators continue to land tuna around the islands. Although the extent of small-boat landings of these migrating species is miniscule when compared to Pacific-wide landings, and minimal compared to landings by all Hawai'i-based fleets, monitoring such trends may bear valuable information about ongoing human interaction with the species of interest in the current climate of concern about the status of the ocean and marine ecosystems.



Source: Hawai'i Division of Aquatic Resources

Figure 17. Catch composition for the MHI handline fishery (all gear types): 1984-2007



Source: Hawai'i Division of Aquatic Resources

Figure 18. Catch per unit effort: MHI handline fishery (all gear types): 1984-2007

4.2 Concluding Management Considerations

4.2.1 Reporting and Data Quality

Descriptive and analytical components of this document are based in part on catch reports provided primarily by fishermen active in one or more of Hawai'i's handline fisheries. As noted previously, reporting has been problematic at certain times and for various reasons that are by no means specific to this region. An obvious management consideration would involve the funding of research that could serve to advance ongoing and new efforts to collect and analyze valid and reliable data regarding catch, effort, and relevant socioeconomic and physical-environmental conditions and factors across the fleets and fisheries in question.

4.2.2 Management of a Self-Limiting Fishery or a Precautionary Approach?

The present decline in participation and production in the ika-shibi fishery is best explained by a range of interactive human and biological factors and processes. This project has attempted to describe and explain the former. While some observers believe the ika-shibi fishery has begun to fade into history, this cannot be said with certainty, as both the biological and social parameters of bigeye and 'ahi fisheries are highly complex and subject to both endogamous and exogenous constraints and opportunities.

In the absence of a more complete understanding of the structure, distribution, and behavioral tendencies of bigeye and yellowfin populations in this context, and of the full range of human effects potentially resulting from a new management regime, establishment of new regulatory constraints for handline or other small-boat fisheries in Hawai'i may be premature. Moreover, it appears that the many challenges encountered by participants in the harvest sector tend to limit participation over time, irrespective of formal regulation.

On the other hand, this research provides evidence to support the intuitive understanding that fishing activity increases when fish are available. Thus, limiting entry

into a given fishery or fisheries and/or controlling the use of highly effective types of gear may be useful means for regulating rapid and widespread escalation of fishing pressure during periods when migrating tuna species are abundant around the islands. Such action may be seen as constituting a precautionary measure to be applied until a better understanding of pertinent issues such as the potential existence of regional tuna stocks and the local effects of fishing such stocks can be attained. But a precautionary strategy can also be envisioned as a means for prioritizing human needs and interests, in which case decisions regarding the scope or nature of a limited entry program would safeguard the well-being of fishermen and fishing-associated communities until better biophysical data and analyses can be generated.

It should be noted here from a sociological perspective that most seasoned participants in the far offshore handline fishery naturally support the idea of limited entry insofar as entry is based on historical levels of performance. Participants in the new deep-set "shortline" fishery have also argued for establishment of a limited entry program. The rationale is that the gear enables productive fishing for mature bigeye and yellowfin, and that if its use is limited to a small group of participants, no overt increase of pressure on tuna populations would occur. Current participants also desire the freedom to explore other seamounts in the region, which reportedly could bring a variety of currently underutilized species to the marketplace (e.g., alfonsins and various shark species).

The Council has, at the time of this writing, determined that it will further its deliberations on limitation of entry into the far offshore fisheries at Cross Seamount and the weather buoys. The full rationale, qualifying criteria, prospective number of entrants, and anticipated human and biophysical effects of this action are not yet clear and will need to be examined through future research and deliberation.

4.2.3 Changing Context and Adaptive Management

Analysis of the historic and contemporary aspects of Hawai'i-based small-boat commercial handline fisheries makes it clear that a variety of biophysical and human variables condition the status of those fisheries at any given point in time. Some such variables appear to manifest in cycles. This is true of fluctuating national and regional economic conditions, for instance, and it appears to be true of the availability and/or abundance of tuna.

Other factors and processes influence the conduct of marine fisheries in linear fashion. For example, developments in gear, vessel, and electronics technologies have tended to increase efficiency in a progressive manner.

Ways and means of managing fisheries and marine resources in Hawai'i have also changed over time. The governance dimension is relatively malleable, with policy-makers and affected groups sometimes drawing on new ideas for effective management, and sometimes borrowing from tested strategies of the past.[16] Further, policy-makers tend to be influenced by the public interest, which tends to vary based on cycles of attention to regional or national environmental events and issues (Downs 1972).

[16] For instance, interest in restoration of ahupua'a-based management of natural resources has grown in recent years. Such interest was recently formalized in Hawai'i Act 212, which specifies the establishment of regional councils ('Aha moku) that will advise policymakers "on all matters regarding the management of the State's natural resources."

Finally, certain conditioning factors and processes are not clearly patterned. For example, it is difficult to assess or predict changes in culturally influenced ideas and behaviors such as those related to involvement in the commercial fishing industry. In certain cultural contexts, the fishing industry and fishing lifestyles are championed, as in some contemporary communities around Hawai'i. In other social settings, commercial fishing is not held in high esteem and youth are guided into other activities and professions.

Given the complex and ever-changing nature of Hawaii's fisheries, adoption of a flexible and adaptive approach to management may be the most prudent way to proceed. Change is inevitable: the status of the national and regional economies will alternately improve and worsen in future years; fishing technology will improve; overarching governance strategies will be subject to new paradigms and/or modeled on past successes; cultural and demographic changes will affect levels of participation in the commercial fishing industry; and new biophysical and social data relating to tuna populations and tuna fisheries will emerge. By retaining options to make temporary resource management decisions and to adjust policies as these and other factors and conditions fluctuate, managers will be engaging in a strategy that best reflects the actual dynamics of marine ecosystems and associated human societies.

REFERENCES

Abbott, I. A. 1992. Lā'au Hawai'i—Traditional Hawaiian Uses of Plants. Honolulu: Bishop Museum Press.

Allen, G. 1950. Hawaii's War Years. Honolulu: University of Hawai'i Press.

Apple, R.A., and W. K. Kikuchi. 1975. Ancient Hawai'i Shore Zone Fishponds: An Evaluation of Survivors in Historical Preservation. Honolulu: National Park Service.

Bartram, P., P. Garrod, and J. Kaneko. 1996. Quality and product determination as price determinants in the marketing of fresh Pacific tuna and marlin. Pelagic Fisheries Research Program Publication, SOEST 96-06, JIMAR Contribution 96-304. Honolulu.

Beckley, E. M. 1883. Hawaiian fisheries and methods of fishing with an account of the fishing implements used by the Natives of the Hawaiian Islands. Honolulu. Reprinted in U.S. Fish Commission. Bulletin No. 6 (1886): 245-256.

Boggs, C. H., and B. S. Kikkawa. 1993. The development and decline of Hawaii's skipjack tuna fishery. In Marine Fisheries Review. Spring 1993. Fisheries of Hawai'i and U.S.-associated Pacific Islands.

Brock, V. 1947. Report of the director. Division of Fish and Game, Board of Agriculture and Forestry. Territory of Hawai'i. Honolulu.

Campbell, A. 1819. A Voyage around the World. New York: Broderick and Ritter.

Chapman, L., B. Pasisi, I. Bertram, S. Beverly, and W. Sokimi. 2005. Manual on fish aggregating devices (FADs): Lower-cost moorings and programme management. Prepared for the Secretariat of the Pacific Community. Noumea.

Cobb, J. N. 1905. The commercial fisheries of the Hawaiian Islands: III. Reprinted in the U.S. Fish Commission. Bulletin No. 23 (1905): 752.

Cordy, R. 2002. The Rise and Fall of the O'ahu Kingdom. Honolulu: Mutual Publishing.

Corney, P. 1896. Voyages in the Northern Pacific, 1813-1818. Honolulu: Thomas G. Thrum.

Department of Business, Economic Development, and Tourism, State of Hawai'i. 2000. Construction and Hawaii's economy. Economic Analysis Division. May. Honolulu.

Division of Aquatic Resources, State of Hawai'i. 1986. Hawaii fisheries plan 1985. Department of Land and Natural Resources. Honolulu.

Downs, A. 1972. Up and down with ecology: the "issue-attention cycle." The Public Interest, 28 (Summer 1972), 38-50.

Emory, K. P., W. J. Bonk, and Y. H. Sinoto. 1969. Waiahukini shelter, site H8, Ka'ū, Hawai'i. Anthropology Department: B. P. Bishop Museum. Honolulu.

Emory, K. P., W. J. Bonk, and Y. H. Sinoto. 1959. Hawaiian Archaeology: Fishhooks. B.P. Bishop Museum Special Publication 47. Honolulu: Bishop Museum Press

Fish Aggregating Device Program, State of Hawai'i. 2006. History of the Hawai'i State FADs Program. Sea Grant College at the University of Hawai'i, and Hawai'i Institute of Marine Biology. Available online at http://www.hawaii.edu/HIMB/FADS/.

Fonteneau, A. 1991. Seamounts and tuna in the tropical Atlantic. Aquatic Living Resources, 4, 13-25.

Glazier, E. W. 2007. Hawaiian Fishermen. Belmont, CA: Wadsworth-Thomson Publishers.

Glazier, E. W. 1999. Social aspects of Hawaii's small vessel troll fishery. Phase II Social aspects of Pacific pelagic fisheries. Pelagic Fisheries Research Program, Joint Institute for Marine and Atmospheric Research, SOEST. University of Hawai'i at Mānoa. 280 pp.

Goto, A. 1986. Prehistoric ecology and economy of fishing in Hawaii: An ethnoarchaeological approach. Thesis (Ph.D.)—Anthropology. University of Hawai'i at Mānoa. Honolulu.

Groube, L. M. 1971. Tonga, Lapita pottery, and Polynesian origins. Journal of the Polynesian Society, 80, 278-316.

Hamilton, M. S. and S. W. Huffman. 1997. Cost-earnings study of Hawaii's small-boat fishery. SOEST 97-06. JIMAR Contribution 97-314. University of Hawai'i at Mānoa, and National Marine Fisheries Service, Honolulu Laboratory. Honolulu.

Hampton, J., P. Kleiber, A. Langley, and K. Hiramatsu. 2004. Stock assessment of bigeye tuna in the western and central Pacific Ocean. SCTB17 Working Paper. Majuro, Marshall Islands.

Hampton, J., P. Kleiber, Y. Takeuchi, H. Kurota, and M. Maunder. 2003. Stock assessment of bigeye tuna in the western and central Pacific Ocean, with comparisons to the entire Pacific Ocean. SCTB 16 Working Paper BET-1. Sixteenth Meeting of the Standing Committee on Tuna and Billfish. Queensland, Australia.

Handy, E. S. C., and M. Pukui. 1972. The Polynesian Family System in Ka'ū, Hawai'i. Rutland, Vermont: Charles E. Tuttle Company, Inc.

Hanneman, R.A. and M. Riddle. 2005. Introduction to Social Network Methods. Riverside, CA: University of California, Riverside. Published in digital form at http://faculty.ucr.edu/~hanneman/

Harley, S. J., and M. N. Maunder. 2004. Status of bigeye tuna in the eastern Pacific Ocean in 2003 and outlook for 2004. Working Group on Stock Assessments, 5th Meeting, La Jolla, California. Document SART-5-05 BET. Inter-American Tropical Tuna Commission. La Jolla.

Hoffman, R. G., and H. Yamauchi. 1972. Recreational Fishing in Hawai'i and its Economic Impact on the State and Local Economies. College of Tropical Agriculture, Hawai'i Agricultural Experiment Station, University of Hawai'i, Departmental Paper. Honolulu.

Holland, K., and D. Grubbs. 2007. Fish visitors to seamounts: tunas and billfish at seamounts. In Pitcher, T.J., T. Morato, P. J. B. Hart, M. R. Clark, N. Haggan, and R. S. Santos (eds.). Seamounts: Ecology, Fisheries and Conservation. Fish and Aquatic Resources Series 12, Blackwell, Oxford, UK.

Holmes, T. 1993. The Hawaiian Canoe. Honolulu: Editions Limited.

Hommon, R. J. 1976. The formation of primitive states in pre-contact Hawaii. Thesis (Ph.D.)—Anthropology. University of Arizona.

Hosaka, E.Y. 1944. Sport Fishing in Hawaii. Honolulu: Bond's.

Ikehara, W. 1981. A survey of the ika-shibi fishery in the State of Hawaii, 1980. U.S. Department of Commerce. NOAA, NMFS, SWFSC Administrative Report h-82-4C.

Itano, D. 2004. Hawaiian-style small-scale deep setting longline technique used on seamounts. SPC Fisheries Newsletter #111. October/December.

Itano, D. G., and K. N. Holland. 2000. Movement and vulnerability of bigeye (*Thunnus obesus*) and yellowfin tuna (*Thunnus albacares*) in relation to FADs and natural aggregation points. Aquatic Living Resources, 13 (2000), 213-223.

Iversen, R. T., T. Dye, and L. M. Paul. 1990. Native Hawaiian Fishing Rights. Phase One: The northwestern Hawaiian Islands, and Phase 2: The main Hawaiian Islands and the northwestern Hawaiian Islands. Prepared for The Western Pacific Regional Fishery Management Council. Honolulu.

Kahā'ulelio, A. D. 2006. Ka'oihana Lawai'a—Hawaiian Fishing Traditions. Translated by M. K. Pukui, and edited by M. P. Nogelmeier. Honolulu: Bishop Museum Press.

Kahā'ulelio, A. D. 1902. Fishing lore. In Nupepa Kuokoa. Translated by M. K. Pukui. February. Bishop Museum. Honolulu.

Kamakau, S. M. 1976. Na Hana a ka Po'e Kahiko (The Works of the People of Old). Translated from the Newspaper Ke Au 'Oko'a by M. K. Pukui. Arranged and edited by D. B. Barrere. Bernice Bishop Museum Special Publication 61. Honolulu: Bishop Museum Press.

Kaneko, J., P. Bartram, M. Miller, and J. Marks. 2006. Local fisheries knowledge: The application of cultural consensus analysis to the management and development of small-scale pelagic fisheries. Project Final Report. SOEST 00-06, JIMAR Contribution 00-334. Pelagic Fisheries Research Program. Honolulu: University of Hawai'i at Mānoa.

Kimura, Y. 1988. Issei. Japanese Immigrants in Hawaii. Honolulu: University of Hawai'i Press.

Kirch, P. V. 1985. Feathered Gods and Fishhooks: An Introduction to Hawaiian Archaeology and Prehistory. Honolulu: University of Hawai'i Press.

Kirch, P. V. 1974. The chronology of early Hawaiian settlement. APAO, 9, 110-119.

Konishi, O. 1930. Fishing industry in Hawai'i, with special reference to labor. University of Hawai'i. Honolulu.

Kosaki, R. H. 1954. Konohiki fishing rights. Honolulu: Legislative Reference Bureau, Report Number 1.

Law, C.K. n.d. The economics of deep-sea sport fishing in Hawaii. Paper probably written around 1971 during tenure at the University of Hawai'i, Department of Agricultural Resources. Honolulu.

Lyman, A. L., Inc. and Hawaii Opinion, Inc. 1984. Economic and financial analysis of Hawaii's longline and handline fisheries. Prepared for the National Marine Fisheries Service, Southwest Fisheries Center, Honolulu Laboratory. Administrative Report H-84-17C. Honolulu.

Malo, D. 1951. Hawaiian antiquities: Mo'olelo Hawai'i. 2nd ed. (N. B. Emerson, Trans.). Bernice P. Bishop Museum special publication 2. Honolulu, HI: Bishop Museum Press. (Original work published 1898).

Maly, K., and O. Maly. 2003. Ka hana lawai'a a me na ko'a o na kai 'ewalu. A history of Fishing Practices and Marine Fisheries of the Hawaiian Islands. Kumu Pono Associates. Prepared for the Nature Conservancy and Kamehameha Schools. Hilo.

Markrich, M. 1994. Status report on the economic characteristics of ocean recreation in Hawaii. State of Hawai'i Department of Business, Economic Development and Tourism, Ocean Resources Branch. Honolulu.

McConnell, K. E., I. E. Strand, and R. E. Curtis. 1998. An analysis of auction prices of tuna in Hawaii: Hedonic prices, grading and aggregation. Pelagic Fisheries Research Program. SOEST Publication 98-03, JIMAR Contribution 98-317.

McGregor, D. P. 2007. Nā Kua'āina: Living Hawaiian Culture. Honolulu: University of Hawai'i Press.

Meller, N. 1985. Indigenous Ocean Rights in Hawaii. Honolulu: University of Hawai'i Sea Grant College Program, Sea Grant Marine Policy and Law Report.

Nakayama, M. 1987. Maritime industries in Hawaii: A guide to historical resources. Honolulu: The Humanities Program of the State Foundation on Culture and the Arts in cooperation with The Historical Society.

Nelson, P. 2003. Marine fish assemblages associated with fish aggregating device: effects of fish removal, FAD size, fouling communities, and prior recruits—FADs. Fishery Bulletin. October.

Newman, S. 1970. Hawaiian fishing and farming on the island of Hawai'i: A.D. 1778. State of Hawai'i, Department of Land and Natural Resources. Honolulu.

Oliver, D. 2002. Polynesia in Early Historic Times. Honolulu: Bess Press.

Peterson, S. B. 1973. Decisions in a market: A study of the Honolulu fish auction. Thesis (Ph.D.)—Anthropology. University of Hawai'i at Mānoa. Honolulu.

Pooley, S. G. 1993. Hawaii's marine fisheries: some history, long-term trends, and recent developments. In *Marine Fisheries Review*, vol. 55, no. 2. National Oceanic and Atmospheric Administration, U.S. Department of Commerce. Scientific Publications Office. Seattle.

Preston, G., L. Chapman, and P. Mead. 1998. Vertical longlining and other Methods of Fishing around Fish Aggregating Devices (FADs)—A Manual for Fishermen. Secretariat of the Pacific Community. Noumea.

Pukui, M. K., and S. H. Elbert. 1986. Hawaiian Dictionary. 6th Edition. Honolulu: University of Hawai'i Press.

Research Associates. 1977. A study of the bioeconomic and optimal management criteria for utilization of Pacific billfish, Module I. Unpublished contract report prepared for the National Marine Fisheries Service, Honolulu Laboratory.

Rizzuto, J. 1977. Modern Hawaiian Gamefishing. Kolowalu Books. Honolulu: University of Hawaii Press.

Rodgers, S. 1987. Description of the ika-shibi technique. In Fishing Hawaii Style, Vol. 2. Jim Rizzuto (ed.). Fishing Hawaii Style Ltd., Honolulu, Hawaii.

Sahlins, M. 1992. Anahulu: The Anthropology of History in the Kingdom of Hawaii. vol. 1, Historical Ethnography. Chicago: University of Chicago Press.

Sahlins, M. 1989. Captain Cook at Hawaii. Journal of the Polynesian Society, 98, 371-423.

Schug, D. 2001. Hawaii's Commercial Fishing Industry: 1820-1945. The Hawaiian Journal of History, 35, 15-34. Publication of the Hawaiian Historical Society. Honolulu.

Scobie, R. 1949. The technology and economics of fishing in relationship to Hawaiian culture. Dissertation (M.A.). London School of Economics.

Secretariat of the Pacific Community. 2009. Annual report 2008. Oceanic Fisheries Programme. Noumea.

Secretariat of the Pacific Community. 2008. Update on tuna fisheries. January 2008. Available online at http://www.spc.int/oceanfish/Docs/Tuna%20Fisheries_1-2008.pdf.

Shomura, R. S. 1987. Hawaii's marine fishery resources: Yesterday (1900) and today (1986). Southwest Fisheries Center Honolulu Lab., National Marine Fisheries Service, NOAA, Honolulu. Southwest Fisheries Center Administration Rep. H-87-21, 14 p.

Sibert, J., J. Hampton, P. Kleiber, and M. Maunder. 2006. Biomass, size, and trophic status of top predators in the Pacific Ocean. Science, 314, 15 December.

Sinoto, Y. H. 1962. Chronology of Hawaiian fishhooks. Journal of the Polynesian Society, 71, 162-66.

Stannard, D. 1989. Before the Horror: the Population of Hawaii on the Eve of Western Contact. Social Science Research Institute, University of Hawai'i at Mānoa. Honolulu: University of Hawai'i Press.

Streck, C., and F. Watanabe. 1988. Archaeological renaissance of areas proposed for emergency flood control repair and replacement of structures, Bellows Air Force Station (BAFS), Waimanalo Districts, O'ahu Island. Manuscript U.S. Army Corps of the Engineers, Fort Shafter, O'ahu.

Titcomb, M. 1972. Native Use of Fish in Hawai'i. Honolulu: University of Hawai'i Press.

Titcomb, M. 1953. Native Use of Fish in Hawai'i. Memoir 29, Supplement to the Journal of the Polynesian Society. With the collaboration of Mary Kawena Pukui. Installment No. 3, 147-162.

Tomita, H. S. 1940. Nisei [sic] Japanese fishermen. In *Paradise of the Pacific*, Vol. 2., January.

Tuggle, H. D., R. Cordy, and M. Child. 1978. Volcanic glass hydration-ring age determination for Bellows Dune, Hawaii. *New Zealand Archaeological Association Newsletter*, 21, 57-77.

United Japanese Society of Hawai'i. 1971. A history of Japanese in Hawai'i. Edited by Publication Committee, J. Okahata, Chairman, XIX, 91. 431 p.

Wessel, P., and B. H. Keating. 1994. Temporal variations of flexural deformation in Hawai'i. *Journal of Geophysical Research*, 99, 2747-2756.

Western Pacific Regional Fishery Management Council. 2007. Pelagic fisheries of the western Pacific region—2006 Annual Report. Honolulu.

Western Pacific Regional Fishery Management Council. 2003. Managing marine fisheries of Hawaii and the U.S. Pacific Islands—Past, present, and future. October. Honolulu.

Yuen, H. S. 1979. A night handline fishery for tunas in Hawaii. Marine Fisheries Review, 41, 8.

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